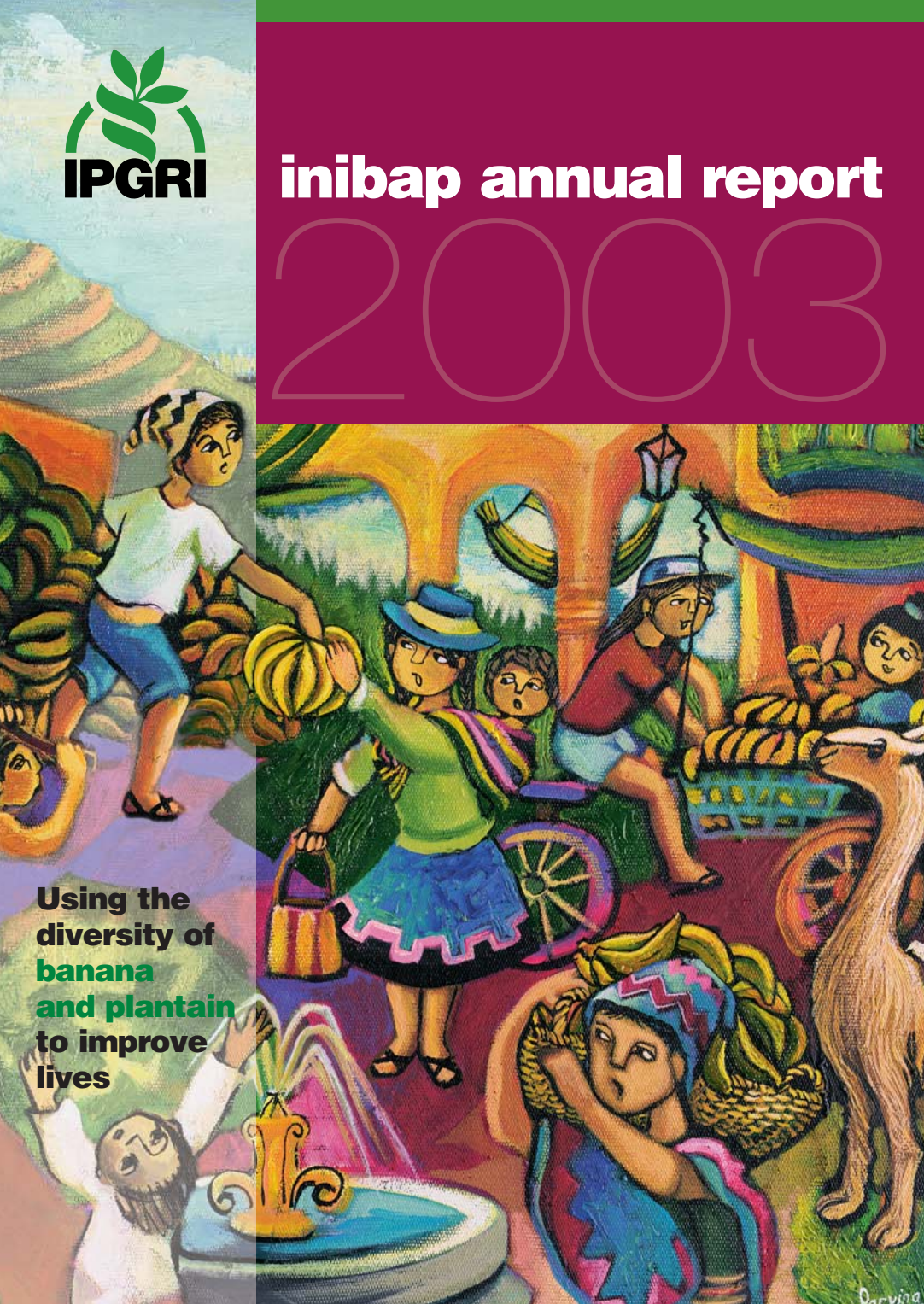
IPGRI

inibap annual report 2003



Using the diversity of banana and plantain to improve lives

Foreword

For this year's Annual Report of the International Network for the Improvement of Banana and Plantain (INIBAP), we are experimenting with a different format. In previous reports, we tried to provide a broad overview of INIBAP's activities in the year and those of INIBAP-coordinated networks and programmes, leavened with 'focus papers' of broader scientific interest. However, with the launch of initiatives like the genomics consortia, it has become increasingly difficult to report adequately on the extensive work of the partners while distinguishing it from INIBAP's own efforts.

Partly for this reason we decided to use a more selective approach, looking in greater depth at a few collaborative projects, analysing the lessons learned in a manner which we hope will be interesting to a broad range of readers in the agricultural research and development community, and then providing only a brief summary of the rest of our programme, in a form which will be mainly useful to our donors and other immediate partners. And in an attempt to make the publication accessible to the widest possible community of readers, we have decided to publish separate versions of the report in INIBAP's three official languages – English, French and Spanish. Please let us know what you think.

This year's Annual Report is divided into two sections. In the first section, we include four in-depth stories that illustrate different aspects of INIBAP's work to conserve and disseminate *Musa* genetic resources and to help people use *Musa* diversity to improve livelihoods. One story explains how farmers in the Bolivian hinterland are learning how to meet international standards for organic banana production - and in the meantime are gaining access to more profitable markets in the Bolivian capital, La Paz. The second story explains how INIBAP and its partners are learning from farmers in Africa which kinds of new variety they prefer and how they put them to use, either to substitute for traditional cultivars or to provide new economic opportunities. The third story recounts how Ugandan scientists are being empowered to use the latest tools of biotechnology to confer disease resistance on the traditional *matooke* varieties that provide the main staple food in their country. And the fourth story describes how *Musa* germplasm, originally collected in Asia and subsequently used in breeding programmes on the other side of the world, is now being brought back to countries like the Philippines in the form of improved varieties, re-evaluated and put to use by smallholder farmers. The second half of the report provides a concise review, project-by-project, of INIBAP's collaborative research-and-development activities, including a summary of progress achieved by the PRO*MUSA* breeders' network and the Global *Musa* Genomics Consortium, both coordinated by INIBAP.

It is no accident that the stories highlighted in this year's report focus on the development impacts of our work, rather than on the technical details of the research involved. For the past several years, INIBAP has sought to assess the impact of its work in terms of *improvements in the livelihoods* of the smallholder banana and plantain farmers who are our primary clients, rather than focusing only on the *productivity* of their banana and plantain farms as mentioned in our existing mission statement. INIBAP is a programme of IPGRI, the International Plant Genetic Resources Institute, and during 2003 INIBAP's staff and other stakeholders have been involved in a far-reaching process to review the strategy of the Institute as a whole. This process will continue during 2004 and you will have to wait for the next Annual Report to see the new strategy formally reflected in a new mission statement for INIBAP. In the meantime, it is clear that our new mission, while including the pursuit of scientific excellence as a means to an end, will focus explicitly on improving the well-being of people, and that building knowledge and learning from experience – at both a personal and institutional level – will play a key role in our search for greater impact. We look forward to working with you as we travel this road ahead.

Richard Markham
Director, INIBAP

Emile Frison
Director General, IPGRI

The mission of the **International Network for the Improvement of Banana and Plantain (INIBAP)** is to increase the productivity and stability of banana and plantain grown on smallholdings for domestic consumption and for local and export markets.

INIBAP has four specific objectives:

- to organize and coordinate a global research effort on banana and plantain, aimed at the development, evaluation and dissemination of improved cultivars and at the conservation and use of *Musa* diversity;
- to promote and strengthen regional efforts to address region-specific problems and to assist national programmes within the regions to contribute towards, and benefit from, the global research effort;
- to strengthen the ability of NARS to conduct research on bananas and plantains;
- to coordinate, facilitate and support the production, collection and exchange of information and documentation related to banana and plantain.

INIBAP is a programme of the International Plant Genetic Resources Institute (IPGRI).

The International Plant Genetic Resources Institute (IPGRI) is an independent international scientific organization that seeks to advance the conservation and use of plant genetic diversity for the well being of present and future generations. It is one of 15 Future Harvest Centres supported by the Consultative Group on International Agricultural Research (CGIAR), an association of public and private members who support efforts to mobilize cutting-edge science to reduce hunger and poverty, improve human nutrition and health, and protect the environment. IPGRI has its headquarters in Maccarese, near Rome, Italy, with offices in more than 20 other countries worldwide. The Institute operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme and (3) the International Network for the Improvement of Banana and Plantain (INIBAP).

The international status of IPGRI is conferred under an Establishment Agreement which, by January 2003, had been signed by the Governments of Algeria, Australia, Belgium, Benin, Bolivia, Brazil, Burkina Faso, Cameroon, Chile, China, Congo, Costa Rica, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Greece, Guinea, Hungary, India, Indonesia, Iran, Israel, Italy, Jordan, Kenya, Malaysia, Mauritania, Morocco, Norway, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovakia, Sudan, Switzerland, Syria, Tunisia, Turkey, Uganda and Ukraine.

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The European and North American organic banana markets seem tailor-made for smallholder farmers but entering these markets is not without its own sets of difficulties, as INIBAP and its partners learned when they went down that road in South America.

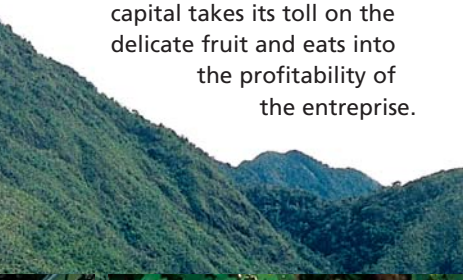
The highs and lows of organic bananas in South America

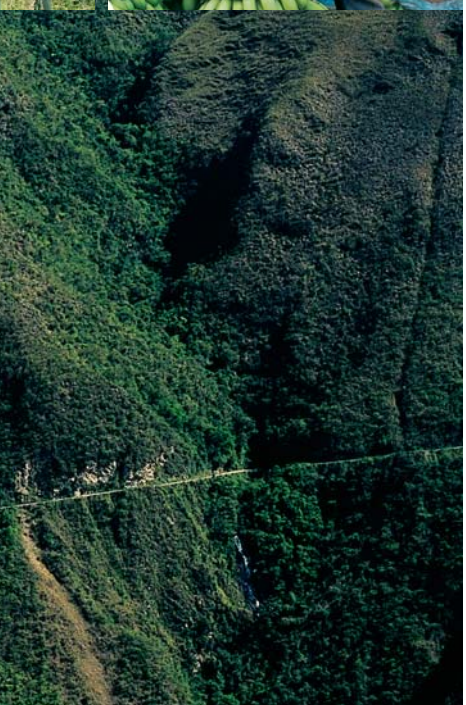
Bolivian farmers are pushing up the quality of their bananas, using improved infrastructure such as packing stations and cableways (A. Vezina, INIBAP).

"The project is having a positive impact because it has adapted to the situation on the ground"

The road to La Paz (A. Vezina, INIBAP).

"The road is killing us", sighs Fernando Bohorguez, the manager of the Alto Beni organic banana project in Sapecho, Bolivia. Figuratively, that is. Although the road to La Paz does contain a narrow stretch overlooking a 1000-metre drop, Fernando is alluding to its impact on the bananas. Even with a two-lane gravel road set to replace the hair-raising section, the nine-hour trip to cover the 235 km to the high-altitude capital takes its toll on the delicate fruit and eats into the profitability of the entreprise.





The road is one of the reasons the project has yet to deliver on its original promise of exporting organic bananas from this mountainous landlocked country to the more lucrative, but finicky, markets of North America and Europe. The goal of improving the lives of Alto Beni farmers, however, has been attained, thanks to a good dose of realism. "The project is having a positive impact because it has adapted to the situation on the ground", says Fernando. Instead of immediately competing with established organic exporters in international trade, the project has concentrated on fine-tuning the commodity chain in the domestic market and grooming the 10 producer

associations, one for each participating community, to take over after the project is finished. By improving the quality of the bananas and reducing the costs of packing, transporting and conserving them, the farmers' income increased by as much as 73% in some cases.

Changing attitudes

Before the project, Alto Beni farmers had no choice but to accept the low prices offered by intermediaries – called *chiperos* because they buy the bananas in *chipas,* 1000 fingers – coming down from La Paz with trucks to relieve them of their bananas. The farmers had no incentive to invest time and effort to nurture their plants and fight off diseases. "Before the project", confirms Mario Choque Chamba, the executive secretary of the Alto Beni agro-ecological federation, "the farmers did not look after their banana plants. They would plant them and harvest the fruits, nothing more." There was more to this attitude than strict economics. The majority of Alto Beni farmers migrated to the semi-tropical humid forests flanking the Beni river over the last 40 years. Most of them came from the altiplano, where land was becoming scarce because of population growth and where bananas

Conventional growers sell their bananas in chipas or 1000 fingers (left). Outreach material from the Alto Beni project (centre). The Beni river in Bolivia (right). Fernando Bohórquez explaining how to take care of a banana plant (lower right). *(Photos A. Vezina, INIBAP, illustration R. Sosa Toledo).*

do not grow. Unlike their African and Asian counterparts who inherit a wealth of knowledge on the cultivation of bananas, the Alto Beni farmers were not born in a 'banana culture'.

They did, however, react very sensibly to finding themselves in unfamiliar surroundings and disadvantaged by the rough terrain lying between them and their markets: they spread the risks by growing a variety of crops, many in mixed cropping systems. The banana is one of them because it provides a steady income until the fruit trees with which it is cultivated, mainly cacao and citruses, can be harvested. The farmers own on average 12 hectares, of which around 1.5 ha are for bananas. Ninety percent of the bananas are of the cultivar 'Grande naine'.

Lately, however, the banana plants started to sport the grey drooping leaves characteristic of black leaf streak disease, which entered the area in the late 1990s. Luckily for the 466 farmers participating in the project, not being able to afford chemical fungicides played in their favour when it was proposed that they should prime their bananas to compete in the organic market (see 'The organic banana and the smallholder').

The funds to support the conversion comes from the Inter-American Drug Abuse Control Commission of the Organization of American States (CICAD-OAS), which is part of a US-funded strategy to fight the illegal production of coca based on projects that help farmers grow legal crops instead. Since Alto Beni is not an important coca producer, this project is different in that its objective is to discourage farmers from drifting to the illegal cultivation of coca, not to wean them off. The participating farmers sign a pledge not to grow coca in return for help with their crops and schools, roads, water and electricity — all of which are sorely needed.

The organic banana and the smallholder

Selling organic bananas to health-conscious consumers in developed countries is at the forefront of efforts to help small-scale banana producers improve their livelihoods. For one thing, the market is still open to newcomers. The organic banana trade is a drop in the ocean compared to the 11 million tonnes of conventional bananas exported each year, but in contrast to the latter it keeps on increasing. It shot up from an estimated 29 000 tonnes in 1998 to 136 000 tonnes in 2002 and the forecast is for more growth. Nearly half of the production comes from the Dominican Republic, while Ecuador, Peru, Mexico and Colombia produce most of the remaining half.

Smallholders are also considered ideally suited to supply this niche market since they can rarely afford the chemical pesticides and fertilizers that are banned in organic agriculture. Other constraints, however, hinder conversion. Black leaf streak disease is seen as an important one. Areas that do not have the disease are currently at an advantage, but novel approaches being tested in areas of high disease incidence, such as Ecuador, are producing plants with healthy-looking leaves. The plants are fed a diet of liquid and solid organic fertilizers that incorporate a large variety of microorganisms, which are believed to induce the plant to deploy its defences.

The recurring cost of certification, which is beyond the reach of the average smallholder, is another hurdle. Producers overcome it by forming associations that spread the cost among their members or by signing an exclusivity contract with a marketing company that, in return for paying for the certification, buys their production at a fixed price.

Smallholders also need help during the transition period in which production costs have risen because of the extra work but the sale price of bananas has not changed because the fruits are not certified. It can take up to 3 years to obtain an organic certification. When they are certified, the bananas fetch a better price, in part because consumers are willing to pay more but also because the demand exceeds the supply. The fear is that the price for organic bananas will be brought down as supply exceeds demand and supermarkets and multinationals capture a bigger share of the organic banana trade.

In Alto Beni, bananas are grown in association with citruses *(A. Vezina, INIBAP).*

On becoming an organic farmer

The project was initiated in May 2002 and is administered by INIBAP on behalf of the Bolivian Vice-ministry of Alternative Development. It is far-reaching as it tries to modernize and rationalize the production, handling, transport and marketing of the bananas. Its challenge is to set up a self-sustaining system that will motivate

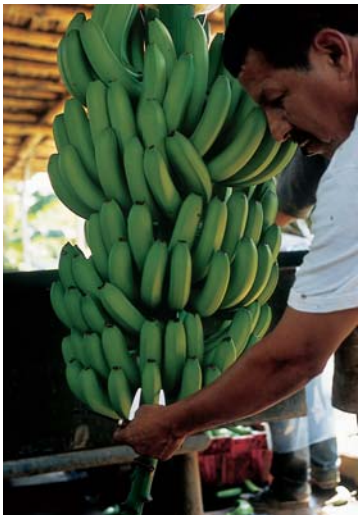
Bananas are grown in association with fruit trees even if it means lower banana yields and farmers with divided loyalties

farmers to put in the extra efforts needed to produce organic bananas that will also be competitive.

To increase quality, farmers were shown practices that improve fruit quality and keep the pest load down. "Before, we were planting too many banana plants close to each other", says Mario Vasquez Canaviri, a farmer known for keeping his plots neat and integrating the new knowledge. "They did not grow well because there was too much shade." Besides planting the right density of banana plants, Mario now de-flowers the young fingers, keeps the mat clean, removes non-functional leaves and the false hands, bags the bunches and selects the best sucker that will keep the cycle going.

The next step is to learn the ins and outs of organic fertilization. "We don't have time to rest", says Mario. "There is always something to do." So far, the hard work has translated into a 30% increase in the quantity of bananas harvested.

Some past practices have been kept since they fit nicely with an organic production system. For example, the farmers are encouraged to continue planting *kudzu*, or *Pueraria thunbergiana*, a leguminous plant that fixes nitrogen and is used as ground cover to prevent erosion and conserve soil moisture.



Organic bananas being graded (upper left). Makeshift pool to wash bananas (centre left). Arminda Callizaya helping out her family during the weekly packing ritual (lower left) *(A. Vezina, INIBAP).*

Mario Vasquez Canaviri, an Alto Beni organic banana producer (right) *(A. Vezina, INIBAP).*

Growing bananas in association with fruit trees has also been retained even if it means lower banana yields and farmers with divided loyalties. "For us it is a problem to the extent that the farmers do not dedicate themselves 100% to bananas. They are sometimes busy harvesting other crops", explains Fernando. "But for them growing more than one crop is less risky. It is also better for the environment than a monoculture." Moreover, another CICAD-funded project is helping farmers get more mileage out of their cacao trees and has made mixing in banana plants a condition for participating in the project.

After the harvest

Another change brought about by the project is the need to pack the bananas in boxes to protect them during transport. Farmers have been taught how to wash them to leach the latex, how to protect them against crown rot and how to pack them. Not all the farmers participating in the project

An organic banana paradise

In 1997, banana production in northern Peru was struggling when El Niño hit, leaving devastated fields in its tracks. Damage was heaviest on the coast but the Chira valley, some 50 km inland, was also affected. The following year, the Peruvian Ministry of Agriculture (MINAG) solicited INIBAP's help to rehabilitate the banana production in the Chira valley with the aim of exporting the bananas. But rather than export conventional bananas into a saturated market dominated by multinationals, Salomon Soldevilla, at the time an agronomist for MINAG and currently INIBAP's co-director of the Alto Beni organic banana project in Bolivia, suggested that Chira valley farmers, who own on average 0.7 hectares, produce organic bananas instead.

Already blessed with class I soils and plenty of irrigation water, the region is also exempt from black leaf streak disease because of its dry climate. To top it off, the production zone is strategically situated 60 km from a port easily accessible by a good road – the perfect spot to grow organic bananas. The only thing missing was money. INIBAP paid for the first certification, four mobile packing stations, soil analyses to design the fertilization programme and advisors but the bulk of the money came from the Peruvian government. "We were given only 10 gallons of gas a month", remembers Salomon. "Sometimes, I was using my own money to visit the producers".

Despite the shoestring budget, the project helped over 1600 farmers, who represent 38% of the Chira valley banana producers, and propelled Peru into the leading pack of organic banana producers. Peru is now the third most important producer of organic bananas, which in 2002 represented an export value of US$ 6.1 million and the real net income of organic banana producers increased by 187% between 1998 and 2002.

Since there were no funds to help the organic producers market their bananas, in 2000, Dole took up an invitation to visit the region with a view to buying part of the production and exporting it on the organic market. It accepted and national companies have since joined the fray. The companies cover the cost of the organic certification for the organic producers who sign an exclusivity contract with them. In addition to the certification, the producers are guaranteed a fixed price for their fruits. Moreover, the reduced supply of bananas on the domestic market has led to an increase in the prices paid to conventional producers. Exporting organic bananas not only benefited the organic producers, it also helped small-scale producers get a better price for their noncertified bananas.

are washing and packing their bananas; some prefer to avoid the extra expense. But for those who do, packing is generally a family affair conducted by the side of the road under a thatched shelter and using a rudimentary pool.

These makeshift packing stations have raised the quality of the bananas but not to the level that can be attained in modern packing stations. So 12 km of cableways linked to four industrial-scale packing stations have been built and will be operational in 2004. Farmers from nearby plots will bring the bananas to the cableway, hook them on and watch them roll away to be washed, graded and packed by people from their community.

The local population is impatient to see the packing stations in action, not least because they will provide jobs. The fact, however, that the packing stations can process far more fruits than the quantities currently grown in the nearby plots worries Salomon Soldevilla, the national co-director of the project. He hopes they will not encourage a conversion to the banana monocultures common in other parts of Latin America.

A Peruvian, Salomon worked on a successful organic banana project in northern Peru (see 'An organic banana paradise') before landing a job with the Alto Beni project, first as a consultant and then as co-director of the project. He has been instrumental in turning around Bana Beni SRL, the La Paz-based marketing company created by the project and owned by the ten producer associations. It is run by the producers' sons and daughters, whose inexperience, however, made for a rocky start.

An audit of Bana Beni in 2003 revealed that the production cost was 50% higher than the price at which the bananas were sold. The company had only one client, losses were increasing and the staff were not trained in handling a highly perishable fruit. Without changes, the company was heading straight for bankruptcy.

Antonio Vilas in the Chira Valley is one of the many producers who converted to organic bananas in the wake of a MINAG/INIBAP project and now sells to Dole *(A. Vezina, INIBAP).*

Six months later, losses were cut to 6%. Eighty-three percent of the small but lucrative school breakfast market in La Paz and neighbouring El Alto has been captured by Bana Beni and the latter has signed contracts worth US$ 284 000 for 2004. Salomon pulls out a graph showing that, if the trend continues, the company will break even before the end of 2004.

Although the school breakfast market represents only 5% of the local demand for bananas, it is an important one for the young company because it pays more for a better quality product. Moreover, not only are children in public schools given a nutritious banana as part of their breakfast, they also get exposed to the concept of organic farming.

Not only are children in public schools given a nutritious banana as part of their breakfast, they also get exposed to the concept of organic farming

On the other hand, the La Paz street vendors, who represent 93% of the market, and the supermarkets, which represent a negligible share of the La Paz market (0.5%), do not pay as well and are insensitive to quality.

The future

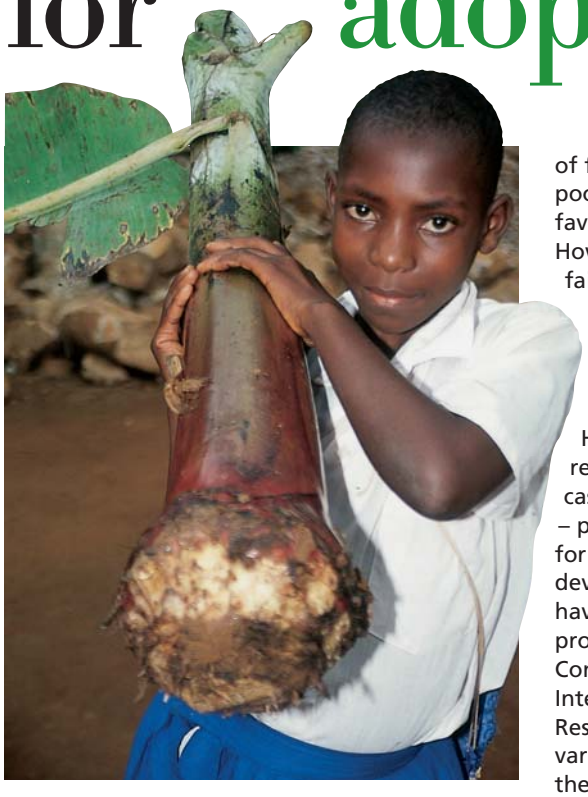
If Bana Beni wants to continue increasing the price it offers organic banana producers, who want their standard of living to keep on improving, it has to find buyers in other countries. The best prospects so far are Chile and southern Peru, only a few hours by road from La Paz. Contacts have been made in both countries and shipments should start in 2004.

Northern Argentina is another possibility. "It is easier for us to sell to the cities in northern Argentina than for Peruvians who have to ship their bananas by boat to Buenos Aires and then load them on trucks to go across the country", explains Fernando. He has not given up on the possibility of sending organic bananas overseas, but he is less convinced than Salomon that it will happen in 2004.

Scheduled to end in May 2004, the project will hopefully be extended to consolidate its achievements and ensure that the changes will outlast the project. As Filomena Mendizabal from the Piquendo association remarks: "A child who has just learned how to walk is not left alone to walk by him or herself."

What does it take to turn a good idea – a disease-resistant variety or novel approach to pest control, for instance – into a practical technology that farmers can use on their own farms to improve their lives and livelihoods? Nowhere is it more pressing to find an answer to this question than in Africa.

Improved hybrids up for adoption



The adoption of even the simplest of technologies can be challenging (D. Mowbray, Baobab productions).

Despite more than thirty years of effort invested by the international agricultural research centres and their partners, there are still disappointingly few examples of green revolution technologies transforming the lives of rural populations in sub-Saharan Africa and providing the hoped-for platform for national economic growth.

Over that period, commentators have variously tried to explain this lack of impact in terms of the 'remoteness' of agricultural scientists, the 'conservatism' of farmers, or in terms of poor soils, harsh climates and favourable economic policies. However, in reality, this is a failure that defies a simple explanation.

Finding the right technologies

Higher-yielding, disease resistant varieties – in our case of banana and plantain – provides a starting point for INIBAP's contribution to development efforts, as they have done for most programmes of the Consultative Group on International Agricultural Research (CGIAR). Resistant varieties are often regarded as the most readily 'adoptable' of improved agricultural technologies because they can reduce farmers' needs for inputs, whether of labour or agrochemicals, and simultaneously reduce the risk of catastrophic losses from pest and disease outbreaks. However, establishing a viable 'seed system' for disseminating new varieties of vegetatively propagated crops like *Musa*, where multiplication rates can be slow and planting material is prone to pest and disease infection, presents even more of a challenge than for cereals or grain legumes.

Two major projects launched by INIBAP and its partners

have tackled this challenge head on, using tissue culture technology to put thousands of plants of new varieties directly into the hands of farmers and then using more conventional multiplication by suckers to subsequently spread the plants from farmer to farmer.

A USAID-funded 'TARGET' (Technology Applications for Rural Growth and Economic Transformation) project, initiated in November 2002 and implemented jointly by the International Institute of Tropical Agriculture (IITA) and INIBAP, works with national research organizations and NGOs in Ghana, Cameroon, Tanzania and Mozambique, while a project initiated in November 2001 and funded by the Common Fund for Commodities (CFC) is working in Guinea, the Democratic Republic of Congo (DRC) and Uganda (as well as Nicaragua, Honduras, Haiti and Ecuador on the other side of the Atlantic). Plantain and banana hybrids, mainly from the *Fundación Hondureña de Investigación Agrícola* (FHIA), but also from the *Centre africain de recherche sur les bananiers et plantains* (CARBAP), and IITA, are the major new technology on offer.

In the TARGET project some 16 000 plantlets were shipped to each of the participating countries in the first year and distributed to 500 farmers in each country. Each country chose four improved hybrids in keeping with local preferences and market potential and each farmer received eight plants of each hybrid. Local nurseries were established to harden off the tender tissue culture plantlets before they were distributed to farmers for planting in their fields.

In Ghana and Cameroon, the plantlets arrived five to six months after the start of the project, which is a significant portion of time in the life of a two-year project. "Delivery delays discouraged some farmers. At the beginning they were very enthusiastic but after they were obliged to clear their plots several times, they began to lose heart" a member of the project team in Cameroon acknowledged ruefully. Moreover, the farmers were not easily convinced that they should try new banana varieties lacking the familiar characteristics of plantain.

Making the most of delays

Delivery delays also occurred in Tanzania and Mozambique, but these were intentional to make the arrival of the plantlets coincide with the beginning of the rainy season. Tissue culture plants have several advantages, but they are relatively demanding of water and nutrients in their first months in the field and need to be transplanted under the best conditions possible to ensure their survival. In the absence of irrigation, the plants could only be delivered to farmers once the rain had arrived.

In Tanzania, project staff put the delay in the supply of tissue culture plants to good use. Drawing on the experience (and planting materials) from an earlier improved varieties project, they established demonstration plots in many villages so that farmers and consumers could get used to the appearance and taste of new varieties before they were offered plants to grow for themselves. Over all, the reaction of farmers has been cautiously positive, with most prepared to give some of the new materials the benefit of the doubt and at least try them out.

In each country, farmers have been trained on how to prepare clean suckers for multiplication – so that the planting material does not carry pests to new fields and so undermine the gains offered by the new

Left: ***Connie Fraser from ITSC explains to banana farmers in Mozambique how to improve planting technique*** *(G. Blomme, INIBAP).*

Right: ***Improved varieties receiving a warm welcome at Loum Km 99, Cameroon*** *(A. NkakwaAttey, INIBAP).*

Farmers in West Africa watch planting techniques first-hand at CARBAP *(A. NkakwaAttey, INIBAP).*

Nursery plants awaiting distribution *(A. NkakwaAttey, INIBAP).*

varieties. In the second year of the TARGET project, each participating farmer will be giving away suckers of the new varieties to at least one other farmer. Evidently, just a few plants distributed to farmers will not change a production system overnight, but the numbers can mount up surprisingly quickly. More than 50 000 plants have so far been established in 40 TARGET villages. And over the course of five years, each of these plants could potentially give rise to at least 100 more.

Meanwhile two years into the CFC project, 14 demonstration plots have been set up to introduce farmers to the hybrids and cultivars offered for evaluation in their fields. However, the farmers will not all be evaluating the same material, partly because the multiplication techniques are different. In DRC and Guinea, rapid corm multiplication techniques are used. As this is, despite its name, a relatively slow process, the multiplication had to be started before the farmers had viewed the plants in the demonstration plots. In this case, farmers will be evaluating the same assortment of improved hybrids (between 10 and 14) as are planted in the demonstration plots.

In Uganda, on the other hand, tissue culture is used to multiply the planting material and only the varieties selected by farmers and technicians – FHIA-17, FHIA-18, FHIA-23, FHIA-25 and the local cultivars 'Nakitembe'and 'Mpologoma' – will be multiplied.

"Comparing the logistics and costs of these methods will be a central component of the second half of the project", says Charles Staver, the INIBAP project coordinator based in Montpellier, France. "The challenge is to find the right supply approach for large-scale planting of the appropriate hybrids and cultivars, while ensuring that the planting material is affordable for smallholders and guaranteed free of diseases and pests. It is important because we should apply the lessons we learn to other projects undertaking the dissemination of new *Musa* germplasm."

"We should apply the lessons we learn to other projects"

Developing markets and business skills

Establishing a reliable, cost-effective supply of planting materials of new varieties, though challenging enough in itself, is only an initial step in the adoption process. For many farmers, the prohibitive cost of credit and the problem of raising collateral for a loan is a major constraint to investing in new technology. The CFC project includes a loan component, intended to provide credit to farmers wishing to purchase extra planting material and other inputs to increase production.

But with new varieties and new production skills in place what will farmers do with the

increased supply of fruit? In areas of food scarcity, communities may be glad to absorb increased production, even if the taste and texture of the new varieties differ from what they are used to. But if new varieties are to translate into increased incomes this may imply identifying new and different markets. The TARGET project includes a component to assess market opportunities for the new fruit but within the short timeframe of the project, farmers will have little chance to put these to the test. The CFC, however, has a four-year run and should be able to go further down the road to market-oriented production.

Scaling up production to meet the needs of the nascent food processing industry is certainly an option for enterprising farmers. Indeed a number of individual experiences point in this direction. Mrs Olomi for instance, a former school teacher from Arusha in Tanzania, produces a banana wine that competes with the cereal-based beers produced by industrial breweries (see 'Mrs Olomi's banana wine'). At the beginning she relied on 'back kitchen' methods, but she has since developed a sizeable brewing and bottling plant. "We can use bananas of any variety", she explained to a meeting of the Banana Research Network for Eastern and Southern Africa (BARNESA), "Our main constraint is to secure a reliable supply of banana". This is surely where the new high yielding varieties really come into their own.

Although the regional research organization, ASARECA, under whose umbrella BARNESA operates, has for some time had an explicitly market-oriented perspective, many of its networks have tended to bring together mainly researchers from national organizations. This is beginning to change and a significant proportion of the participants in this year's BARNESA planning meeting came from the private sector – from tissue culture labs and farms, from food processing businesses and enterprise development consultancy firms. This new focus on promoting enterprise is reflected in the workplans of BARNESA and of INIBAP's regional offices for the year ahead; and brings with it the promise of providing an economic stimulus to technology adoption.

With the real value of traditional export crops declining, African countries are increasingly looking to non-traditional options to re-build their economies and encourage the development of local commercial and business enterprises. The new banana and plantain hybrids offer opportunities for farmers to break into the potentially lucrative markets for processed products such as banana juice, beer and snack foods like chips.

By stimulating farmers to reflect on how they can market improved hybrids and encouraging researchers to engage broadly in the adoption process, the TARGET and CFC projects should contribute to the generation and uptake of technologies that really can improve livelihoods.

Mrs Olomi's banana wine

From the humble beginnings of learning how to make banana wine from a family relative, Mrs Olomi has created a business with 70 full-time employees. Banana Investments Ltd., based in Arusha, Tanzania, makes three brews: a golden, sweet 9% wine called Malkia, a similar dry wine called Meru and Raha, a 7% beer. The beer and the wines are cheaper than regular commercial beers on the market, and offer a more refined taste than local home-brews.

The company's current market is still relatively restricted, geographically speaking. But the growth of the operation in the eleven years since it was launched suggests that Mrs Olomi has found a niche in the market; a niche that could be exploited in other parts of Tanzania and East Africa too. The banana is an attractive ingredient because of its availability year-round. The company gets through nearly 700 metric tonnes of peeled bananas annually, mainly from the farmers in the neighbourhood. However when local supply runs dry the Banana Investment trucks run the gauntlet of the many poorly maintained roads to scout for excess production on the slopes of Mount Meru and Kilmanjaro and even to the coast at Tanga. Increased local production of banana would, no doubt, help save time, cut costs and reduce the wear and tear on the vehicles. But there are other constraints too: the challenges of finding sources of capital to invest in the expensive bottling machinery and building up marketing expertise in the staff, especially the truck drivers who work as the salesman too. Improved agricultural production can help power the development of businesses like Banana Investments but the socioeconomic environment needs to be accommodating too.

New planting material is distributed in the rainy season to provide favourable conditions for establishment *(A. NkakwaAttey, INIBAP).*

To help improve their ailing bananas Ugandans are boldly entering the world of biotechnology. In building up their knowledge base they are drawing expertise from a whole bunch of research institutes.

Gene power fuels an African agricultural revolution

When President Yoweri Museveni of Uganda cut the ribbon to open his country's newly equipped biotechnology laboratory in August 2003, he opened the way to a new chapter in agricultural development history. Within months, Ugandan scientists are expected to carry out the first genetic transformation of the country's own matooke bananas.

Matooke are a group of cooking banana varieties that perform the daily function of providing staple food and income to millions of East Africans (see 'Matooke - a

The National Agricultural Biotechnology Centre near Kampala will allow Uganda to take part in the biotechnology revolution rather than having it forced upon them *(INIBAP).*

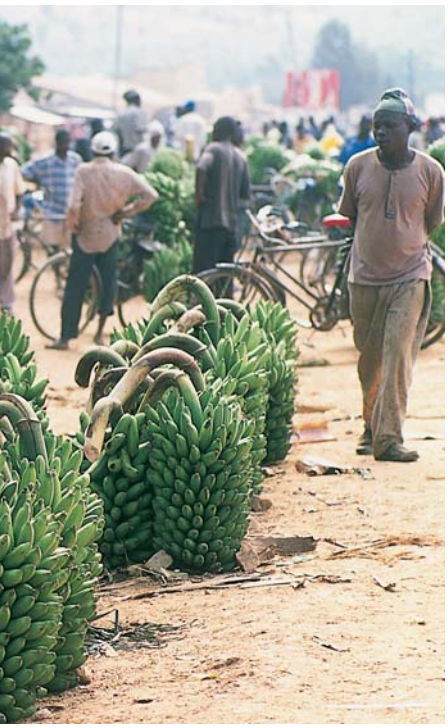
Matooke provide the daily meal for 40 million people but they can only be found in East Africa *(Clive Boursnell, IPGRI)*

mighty meal'). In Uganda matooke are playing a key part in a programme, currently under way, to transform agriculture. The government's plan is founded in policy such as the National Science and Technology Policy and the Plan for Modernisation of Agriculture. This is the first time that matooke is the focus of cutting edge science.

The research took off in 2000 with the launching of a Ugandan-funded biotechnology project at the National Agricultural Research Organization (NARO), coordinated by INIBAP. The *Katholieke Universiteit Leuven* (KULeuven) in Belgium, *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD) in France, the International Institute of Tropical Agriculture (IITA) in Uganda, the John Innes Centre (JIC) in the UK, the University of Pretoria in South Africa and a growing list of other research institutes and universities are providing research and strategic inputs. The Rockefeller Foundation, Belgian Government and USAID are also contributing funds. The tissue culture laboratory at NARO has been revamped and a new laboratory built to carry out advanced molecular studies. When President Museveni inaugurated the laboratories, now known as the National Agricultural Biotechnology Centre (NABC) in 2003, he used the occasion to tell the world that Uganda is now "fully mobilized to accept biotechnology" (see 'The making or breaking of public acceptance to GM bananas').

'If you haven't eaten matooke you haven't eaten'

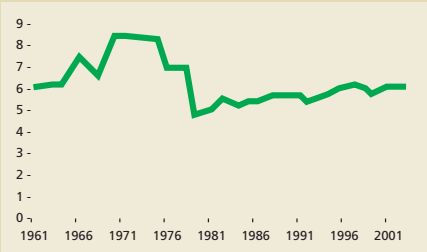
Matooke are playing a key role in transforming agriculture *(Clive Boursnell, IPGRI).*



Matooke - a mighty meal

Matooke, as well as being the term used for a number of cooking bananas, literally means 'food' in Uganda. 'If you haven't eaten matooke you haven't eaten'. This may resound more clearly to those who have visited Uganda and gained weight from eating the appetite-beating matooke dishes. Together with another set of bananas that are used for brewing a high-nutrient beer, matooke form the 100 or so cultivars known as East African highland bananas (EAHB). All this variety, no less than 10% of total cultivated banana diversity, is confined to East African countries. You will not be able to find a decent matooke once you cross the Congo Basin or fly over the Indian Ocean.

In 1961, yields of matooke were 6 tons/ha. Although yields have since risen and fallen, Ugandans in 2003 were still harvesting only 6 tons of matooke per hectare (see figure). In contrast, the country's population has more than tripled — from seven million in 1961 to 25 million in 2002. If matooke is to continue providing a solid basis for food security, improvements have to be made.



Matooke escaped the green revolution — just like many other regionally important crops. The improved banana varieties that are becoming available are useful for many purposes but they do not taste or cook like matooke. Working with modern biological techniques provides Ugandans with the chance to increase yields and keep their matooke.

Yields (tons/ha) of cooking banana in Uganda between 1961 and 2003. *Source FAOSTAT.*

What biotechnology offers

Part of the appeal of biotechnology is that it offers the possibility of injecting one or several useful genes into a crop variety without changing its existing characteristics. This should allow Ugandans to target the specific problems that they encounter and develop a genetic solution in any one of the diversity of bananas that they value. Most persuasively researchers estimate that they can create new bananas in 10 years or less this way. Most cultivated bananas, including matooke, are stubbornly sterile and to breed them conventionally takes years of dedicated persuasion and typically involves crossing them with distant fertile relatives having very poor fruit qualities. Faced with low crop yields and rising population figures, Ugandans have little choice but to react quickly or to change their national diet. The Ugandan biotech project focuses on three main aims: 1) identifying genes that confer resistance to nematodes, black leaf streak disease (also known as black Sigatoka) and weevils; 2) developing the starting materials from matooke that are transformable, and 3) perfecting the technique for transferring target genes into the matooke. A small team of Ugandan scientists runs the laboratories. Much of the project's first two years was dedicated to exchange visits between partner institutes and Uganda to provide the NABC team with the training they needed to run a top class molecular lab. It is here that Priver Namanya, a tissue culture specialist, and her assistants are developing the starting materials, namely

Loice Natukando, one of the team of Ugandan scientists who are developing the starting material for genetic transformation *(P. Namanya, NARO).*

The making or breaking of public acceptance of GM bananas

President Museveni's public acceptance of biotechnology was not without precedent in sub-Saharan Africa. Kenya, South Africa, Nigeria and other nations in the region are pursuing biotech-based solutions to agricultural problems. However, the counter-current in Africa against genetically modified (GM) food is potentially as large as it is in Europe.

As far as biosafety goes, the Ugandan Government has set up a national committee to formulate the legislation that will help to ensure the safety of GM products and biotechnology research. No GM plants will be accepted or developed in the country until the legislation is in place. The confinement facilities at the NABC will conform to international standards.

In Uganda, transformed bananas would evade some of the problems posed by other GM crops elsewhere by being sterile and unable to cross with related species or varieties in the vicinity. The risk that transgenes disperse into the native banana population is minimal.

There are differences between Africa and Europe. Most African consumers are also the growers. There is no mystery and fewer commercial giants behind the growing or selling of food. People's hard work relates directly to what they produce and savings in labour or increases in yield may be easily appreciated. Of course, the imperative for a reliable source of daily food is felt more keenly in Uganda where the average person consumes a daily 2 238 kilocalories compared to 3 230 kilocalories in Europe and 3 754 kilocalories in the USA.

Weevils and nematodes are today's devils we know. The new bacterial disease that has recently invaded East Africa is the devil we don't know. By developing biotechnological capacity to respond to potentially serious diseases, Ugandans are in a better position to safeguard their unique bananas that play such a prominent role in daily life. People may just find that a GM matooke is better than no matooke at all!

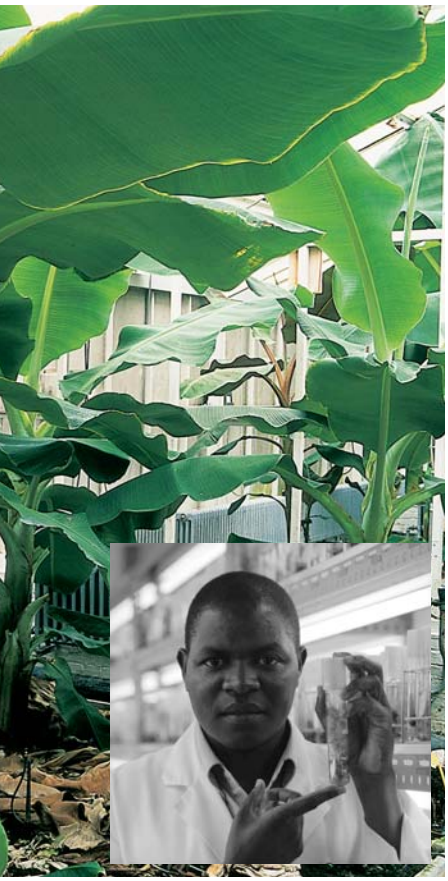
embryogenic cell suspensions (ECS) for eight East African highland banana (EAHB) cultivars. An ECS consists of undifferentiated master cells, or stem cells, each capable of regenerating into a whole organism. The cells are extracted from the growing points in the plant such as meristems or immature flowers and, using a custom-made growth medium, are coaxed into a naïve state where they become capable of acting like embryos. Introducing new genes at this stage means the whole plant will take up the new genetic capability and there is less risk that the plant ends up only partially transformed. Researchers have developed ECS in several banana varieties but, up to the launch of the project, nobody had been able to achieve this for the East African highland cultivars.

It has only been the concerted effort of Priver, with essential advice from different partner institutes, that has finally delivered success. In 2003 embryogenic responses were obtained from cells derived from male flowers of six varieties of EAHB. This, at last, provides the green light for the next steps in the transformation research.

A new generation of experts

Working to elucidate the mechanisms, which can bring to matooke the resistance it needs to deal with problem pests and diseases, are the researchers dispersed in the different partner institutes in Europe and Africa. Geofrey Arinaitwe and Andrew Kiggundu are two of the Ugandan scientists working abroad, Geofrey at KULeuven, and Andrew at the University of Pretoria. They will return with PhD manuscripts and a suitcase full of techniques and materials for use on matooke. Geofrey is adapting established protocols to introduce genes for resistance to black leaf streak disease into banana. He has been using dessert banana and plantain cultivars as models while the team at NABC establish the starting materials from matooke. So far he has successfully inserted two genes (rcc2 and rcg3) from rice that code for the enzyme, chitinase. The cell walls of fungi, such as *Mycosphaerella fijiensis,* the agent that causes black leaf streak disease, are made of chitin. Chitinases have the ability to dissolve the chitin and kill the fungus. Two different gene constructs (see figure), consisting of promoters and terminators (which turn genes on and off), hygromycin phosphotransferase (hpt – a gene which helps select the transformed cells from those that are not), and the rice genes, were integrated independently into the cells of *Agrobacterium tumefaciens*, a microorganism

Andrew Kiggundu grew up eating matooke and appreciates that his work will help improve them *(Rossita Endah, PPRI).*

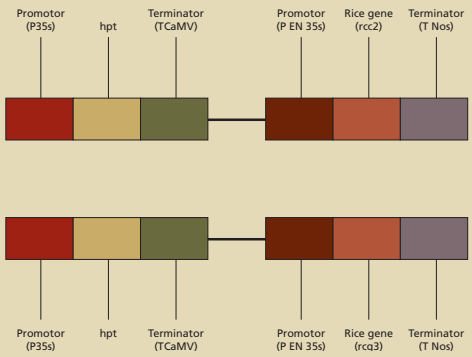


Transformed bananas equipped to resist black leaf streak disease produced as a result of Geofrey's research at KULeuven *(Clive Boursnell, IPGRI).*

Ugandans have little choice but to react quickly or to change their national diet.

Geofrey Arinaitwe, one of the Ugandan students, will return home in 2004 to practice on matooke the transformation techniques he has learnt in Belgium *(Clive Boursnell, IPGRI).*

Two gene constructs carrying a rice gene, rcc2 or rcg3, together with the gene coding for hygromycin phosphotransferase (hpt).



commonly used in transformation work. The transformed bacterium infects the banana cells in the ECS, which then themselves become transformed.

However, diseases have the nasty habit of evolving into new forms that can defeat the resistance built up in the host. Developing new varieties based on one gene alone is not enough for the long term. Instead the researchers are setting their aims at building a 'pyramid' of genes. Geofrey explains "We are aiming at expressing genes coding for antifungal proteins with different modes of action so as to have more durable resistance against black Sigatoka disease".

He has been using a combination of the anti-fungal rice genes together with another gene called Rs-AFP2 that codes for an anti-fungal protein known as a defensin. The *Agrobacterium*-mediated technique appears to be working effectively. However, the quality of the ECS starting material does seem to limit the success of the operation. If the ECS are not fresh and regenerating well, the transformation is restricted. Fortunately, Geofrey will start working in 2004 on the matooke ECS back in Uganda where, at least, freshness should not be a problem.

Andrew's work is focused on the commonly neglected problem of the weevil, the beetle pest that attacks the base of the banana stem. Weevils are pests worldwide but Africa hosts some of the oldest groves of banana plants in the world, dating back more than 100 years. Exchanging plants between neighbours and nursing the same banana groves down the generations has allowed the weevil population to spread and accumulate. The weevil, being one of the few afflictions of the banana to be visible to the human eye, has exaggerated powers to many African farmers. "A farmer sees a plant infected with black Sigatoka and will say that the problem is caused by the insect that eats the plant from underground", says Andrew who was brought up in a banana-producing area.

Naturally occurring proteins, known as cystatins, in other terms a cysteine proteinase inhibitor, can debilitate digestive enzymes in the weevil's gut and effectively starve the insect to death. Genes coding for cystatins exist in various crops but the resulting protein is not always effective at attacking the proteinase enzymes and killing the weevil. The challenge, in this case, is to boost the performance of the gene so that it works effectively against banana weevils.

Andrew intends to tweak cystatin-encoding genes from rice and papaya (OC-I and PC-I). First he needs to find out which cystatins will work on the weevils specific to the banana, and then which part of the genetic sequence coding for these cystatins should be changed in order to improve the weevil-beating performance of the protein.

Of the proteinases that are detectable in the weevil gut, five appear to be inhibited by the rice cystatin and an artificial cystatin called E-64. Furthermore weevil larvae fed on cystatin-laced banana stem disks show severely reduced development. Next, to get ideas of how to boost its performance, Andrew has been studying the genetic sequences of cystatins from 30 plant species. This has given him an idea of where changes have occurred during the evolution of the gene and which parts of the sequence he might target in order to enhance the performance of the gene against banana weevils.

Savings in labour and increases in yield potentially offered by a GM matooke may be welcomed by Ugandans *(Clive Boursnell, IPGRI).*

The first modified genes will be available for testing in 2004. "Because they are mutants that I have developed, we will have the rights to them", Andrew emphasizes, alluding to the fact that much transformation technology is protected by patents and requires negotiation for access to be gained.

Piecing together the puzzle

The making of the super-matooke will depend on piecing together the work of Andrew, Geofrey, the team at

NABC and the other partners in the project. As an example of the latter, laboratories at KULeuven, JIC and the University of Leeds are investigating different proteins and genes to convey resistance to nematodes. And there are more questions to answer. Inhibitors and proteins may work against pests and diseases outside the plant but the equivalent genes inserted in the genome or transformed plants in the farmers' fields may not be able to generate the same effect. This kind of research can take years to resolve.

One of the most valuable aspects of the project, however, is the collaboration it has generated. Starting out with six partners, the project rapidly made new connections with other research institutes working in the area. The University of Pretoria, with its excellent laboratory facilities at the Forestry and Agricultural Biotechnology Institute (FABI), became host to two of the five PhD students. The JIC readily lent its expertise in genetic transformation. Most recently the *Corporación Colombiana de Investigación Agropecuaria* (CORPOICA) in Colombia has agreed to share their experience in developing transformed bananas that are resistant to weevils. IITA are also moving their entire genetic engineering programme on banana, currently based in Nigeria, to the NABC in Uganda.

Andrew hopes that biotechnology will become routine business.

Biotechnology as part of a balanced strategy

Long-term resistance to pests and diseases cannot be achieved through a single strategy alone. Hand in hand with improved banana varieties go better management techniques, post-harvest technologies, supportive policy and many other elements, not least effective communication between farmers, extension agents and researchers. This project is being carried out in a context of diverse initiatives, which focus on on-farm conservation of indigenous banana diversity, farmer-participatory development of integrated pest management (IPM) technologies, exploration of mechanisms to encourage enterprise and better marketing, as well as conventional breeding programmes, including one focusing on matooke led by IITA.

Equally, the findings of the biotech project will help to bring new ideas to bear on other problems. Andrew Kiggundu's research on cystatins for use against the banana weevil could equally target other insects and nematodes. The anti-fungal genes Geofrey Arinaitwe is using are broad spectrum and may be effective against Fusarium wilt as well as black leaf streak disease. The tissue culture laboratory is a facility that can multiply up millions of banana plants to supply clean planting material to large numbers of smallholder farmers.

The collaborative zeal of the partners and the transfer of essential technologies, knowledge and materials to the biotechnology centre in Uganda should potentially allow this developing country and its scientists to progress at an impressive rate. Both Geofrey and Andrew are hoping to continue their bioprospecting and transformation work with other genes and possibly other plants as part of a team of scientists in Uganda.

Andrew expects that biotechnology will become routine business. Doubling banana yields will be a part of the recipe that delivers a wealthier, healthier Uganda and what took European nations a century to achieve should take Uganda little more than a decade (see 'Biotechnology as part of a balanced strategy'). In any case the Ugandans are determined to take part in this particular technological revolution.

When breeders went looking for genes to restore some of the diversity left out of commercial plantations, they headed straight to Asia, where bananas come from. Several decades of hard sweat later, the resulting hybrids are making their way back to Asia to help smallholders fight banana diseases.

Returning home to Asia

Paul Allen – one of the botanists who collected wild bananas and landraces in the 1950s *(Photos: courtesy of FHIA).*

Thanks to sexual reproduction, which shuffles the genetic cards and once in a while comes up with a winning hand, the wild relatives of today's bananas have been able to keep up with pests and diseases. The balance tipped in favour of the diseases when farmers started selecting for parthenocarpic plants, i.e. plants that do not need to be fertilized by pollen to produce fruits and as a result tend to give seedless fruits. As farmer selection took over from natural selection, the vegetatively reproducing banana plants produced better fruit but began to lose ground to the pathogens. Over time, a diversity of cultivars catering to all sorts of tastes and uses was generated by farmers, but at the expense of resistance to diseases.

When the diseases originating in Southeast Asia reached the commercial plantations of Central America, banana breeding programmes were set up to develop resistant varieties. The first thing breeders did was to send off botanists on collecting missions to Asia and the western Pacific to boost their stock of wild *Musa* and cultivars. It took a lot of patience and hard work to blend the best characteristics of wild and cultivated varieties, but each of the breeding centres that has taken up the challenge has turned out hybrids that are resistant to the important diseases (see 'Wild genes in your banana').

INIBAP technical assistant, Angeli Maghuyop, with farmer Macario Mojica in his fields in Cavite, the Philippines, where he is planting improved varieties *(Inge Van den Bergh, INIBAP).*

The case is made for the importance of conserving, documenting and evaluating genetic diversity

Gus Molina with Siti Hawa Jamaluddin at the NRMDC in MARDI, Malaysia *(Nik Masdek, MARDI).*

Many of these improved hybrids are now going back to Asia to help smallholder farmers fight the diseases that are bringing down their yields. A range of varieties, both dessert and cooking bananas, are conserved in the International *Musa* Germplasm Collection in Leuven, Belgium, and evaluated for their yield and resistance to pests and diseases all over the tropical world through the International *Musa* Testing Programme (IMTP). In Asia, as in Africa, INIBAP with its national partners has embarked on an additional phase of varietal assessment by farmers themselves.

First stop

Leading the way is the Philippines, where INIBAP's Asia-Pacific regional office is located. "It is normal that we should start in our own backyard", jokes Agustín "Gus" Molina, the regional coordinator, himself a Filipino. "But the main reason we are the first ones in Asia promoting improved hybrids is that the local banana industry is hit particularly hard by diseases and is looking for alternatives." Funded through the Bureau of Agricultural Research and the Philippine Council for Agriculture, Forestry and Natural Resources, Research and Development, the project has distributed, with the help of provincial and state colleges and universities, as well as non-government organizations, such as local Rotary Clubs, over 30 000 *in vitro* plantlets of selected improved hybrids, FHIA-03, FHIA-18, FHIA-21, FHIA-23 and FHIA-25, alongside the local cultivars 'Bungulan', 'Lakatan' and 'Cardaba'.

Twelve orphanages run by the Virlanie Foundation will be among the first to try out the fruit from the improved varieties. This NGO provides a place to live for 270 children who were previously living on the streets in Manila. One of the orphanages has sufficient land to grow crops. Tended by several of the older children,

Wild genes in your banana

The long history behind the development of every new variety is often little appreciated and sometimes poorly recorded. In classical breeding, genetic diversity is drawn from multiple sources to bring together characteristics for good agronomic performance and tolerance to different stresses in a single variety. The pedigrees behind some of the high-impact wheat and rice varieties are complex, involving hundreds of crosses and germplasm from many sources going back over decades. The history of banana breeding is simpler and thanks to the publication of some obscure notes by the collector, Paul Allen, relating to expeditions in 1959 and 1961, we are able to trace the lineage of a number of improved banana varieties.

Jonathan Robinson, an IPGRI consultant, traced the genetic resource history that led to the making of FHIA-03 as part of an exercise to examine the impact of genetic resources. FHIA-03 was produced by the *Fundación Hondureña de Investigación Agrícola* (FHIA) in 1987 as a cooking banana resistant to black leaf streak disease. The variety has been taken up on a large scale in Cuba, Nicaragua and Tanzania and is rapidly appearing in farmers' plots further afield.

FHIA-03 is a tetraploid (AABB), having four sets of chromosomes each donated from different parents. Breeders started by crossing a triploid (ABB) 'Gaddatu', a cooking banana from the Philippines, and the wild diploid *Musa balbisiana* (BB), probably from either the Philippines or Papua New Guinea.

In total, some 14 crosses involving 11 wild banana types and 2 triploid landraces took place to bring about FHIA-03. Many of the characteristics for pest and disease resistance as well as valuable agronomic traits came from wild bananas. The subspecies, *Musa acuminata* ssp. *burmanica* provided some of the resistance to black leaf steak disease and a wild diploid, 'Pisang jari buaya', provided resistance to nematodes. Crosses between four wild types from Papua New Guinea, Java, Malaysia and the Philippines gave birth to a vigorous diploid (SH-2095), which produces large bunches weighing up to 30 kg, and long fruit that do not fall to the ground when ripe. SH-2095 is a parent of many FHIA varieties.

Asian farmers, then, should find something familiar in the improved hybrids making their way to their fields. Many of the genetic traits of the new bananas originally came from Asia. Although the road has been long and the transactions numerous, the case is made for the importance of conserving, documenting and evaluating genetic diversity, and for the value of sharing resources across regions.

Musa balbisiana ***(top left;*** *Jean-Vincent Escalant, INIBAP)* ***the mother of all plantain is also one of the parents of the improved variety FHIA-03 (bottom right;*** *Franklin Rosales, INIBAP).*

Asian consumers regularly buy or eat bananas of different tastes, shapes and colours *(David Mowbray, Baobab Productions).*

Project leader Telesforo 'Jun' Caminsi (left) with agronomist, Eddy Ynion (third from left) and Alex Gamboa (second from left) and Edwin Reyes (right) from the Virlanie Foundation orphanage standing in front of the newly planted bananas *(Inge Van den Bergh, INIBAP).*

the farm provides fresh produce to the other 11 orphanages. FHIA-18, FHIA-23 and FHIA-25, as well as local varieties 'Lakatan' and 'Bungulan', will soon be on the menu when the newly planted banana varieties come to fruit.

As in previous trials, the FHIA varieties are proving to be high yielding and resistant to the main banana diseases. It is too early to say whether they will be accepted by farmers and consumers, but Gus is confident that the improved hybrids will find a niche in Asia. "Asians are used to bananas of all tastes, shapes, sizes and colours. After all, bananas prepared in many ways provide an important source of food for local people. The improved hybrids just add to this diversity, whereas in Latin America, where people are used to just a few varieties – the Cavendish dessert bananas and one or two plantain cultivars – there is much less interest in improved hybrids, even if they were bred in Central America." According to this theory, the diversity-deprived consumers of Europe and North America should rate low on the uptake scale and there is some evidence to support this argument. Before the 1950s, consumers in the United States were slow to warm up to the Cavendish banana that is so ubiquitous nowadays. They thought it was too different from 'Gros Michel', the only banana they had ever eaten but that could no longer be grown on commercial plantations because of Fusarium wilt. Even if diversity breeds diversity, Gus does not think acceptance will happen overnight. For one thing, the improved hybrids do not taste as good as the local cultivars, he says, all chauvinism aside. "Improved hybrids are an acquired taste. But once you introduce them they will become part of the available diversity and people will get used to them and eat them."

"Improved hybrids are an acquired taste"

For the moment, the new varieties are most likely to win the hearts of farmers through their high yields and disease resistance. Farmers who have difficulties with banana diseases should be the first to adopt them, but one can never predict how events will turn out. For example, as a result of its short shelf-life, FHIA-03 brought out the best in human nature when it was introduced to subsistence farmers in Calamba near Los Baños. A bunch being too big for a single family to eat, farmers started sharing their bounty with their neighbours and soon everybody on the block knew about the new variety.

Plant laundering

The tissue culture plantlets for the project were supplied by the Bureau of Plant Industry of the Department of Agriculture, which has been designated,

Decentralizing germplasm supply

The INIBAP Transit Centre (ITC) in the Katholieke Universiteit Leuven (KULeuven), Belgium, provides a maximum of five samples of any one accession upon request. With a remit for long-term conservation and research, the ITC was never designed to respond to large scale demands for germplasm from farmers. Some smaller genebanks exist to help supply planting material at the regional level, but their reach is limited and quarantine measures can impede the movement of plant materials across borders. National Repository, Multiplication and Dissemination Centres (NRMDCs) represent the best way of getting large amounts of planting material to the farmers who need it.

Seventeen NRMDCs have been set up in 14 countries. Bangladesh, China-mainland, India, Indonesia, Malaysia, Papua New Guinea, Philippines, Fiji, Sri Lanka, Taiwan, Thailand and Vietnam received their *in vitro* plantlets in or before 2003. Cambodia, Myanmar and China-Hainan are expected to receive theirs in 2004. Each country, having received a small grant from the European Union as seed money, is now responsible for keeping the centres going. "They only received about US$ 2000. In a way it is a good thing that we did not have more money because by investing their own resources, the countries put more value on their centre", says Gus Molina, INIBAP's regional coordinator for the Asia-Pacific region.

The inter-regional movement of germplasm dates back to the origins of agriculture and underpins the present day crop varieties that are grown throughout the world. Before 1993, breeders could easily go to the area of origin and diversity of a crop and collect the specimens they needed.

The Convention on Biological Diversity (CBD) affirmed the sovereign rights of nations over their genetic resources. The new policy put a damper on collecting and the movement of plant material and indeed slowed the acquisition of new materials by public in-trust genebanks, such as the International *Musa* Germplasm Collection. Now it is expected that the International Treaty on Plant Genetic Resources for Food and Agriculture, with its provisions on access and benefit sharing, will facilitate the exchange of genetic resources that play a key role in food security and revitalise breeding.

In the meantime, it is hoped that the NRMDCs will promote exchange of germplasm and provide countries with a focus for conserving their landraces and wild relatives of *Musa,* many of which are threatened with extinction.

Inge Van den Bergh, INIBAP scientist based in the Philippines, looks at the effects of banana bunchy top virus which has become a big problem for banana growers in Asia. *(David Mowbray, Baobab Productions).*

together with the Institute of Plant Breeding of the University of the Philippines in Los Baños, as National Repository, Multiplication and Dissemination Centres (NRMDC). These centres are part of a network of similar NRMDCs that have been set up in 14 countries throughout the Asia-Pacific region (see 'Decentralizing germplasm supply'). The NRMDCs were established to provide a ready access to improved hybrids and local cultivars at the national level. The collection is maintained as *in vitro* plantlets and a foundation stock is planted in an insect-proof greenhouse to protect it from insect-transmitted viruses.

What Gus likes best about these centres is that they will be distributing clean planting materials, i.e. free of nematodes, bacteria, fungi and viruses. He wants to enlist these tissue culture plants in the fight against banana diseases, especially viruses, against which the improved hybrids tend to be as powerless as any cultivar. His main target is the banana bunchy top virus (BBTV).

Transmitted by an aphid, BBTV is by far the most serious viral

Bananas in the screenhouse of the NRMDC in the Philippines. Plants from here can be multiplied up and supplied to farmers on the kind of scale that is demanded *(Inge Van den Bergh, INIBAP).*

disease affecting bananas. In the Philippines, where it infects the popular cultivars 'Lakatan', 'Bungulan' and 'Latundan', it constitutes one of the major constraints to production and is also present in many countries in the Asia-Pacific region. Infected plants show stunted growth and rarely produce fruit. Once present, the virus is very aggressive and hard to contain at the farm level, demanding a concerted effort from the entire community.

The disease situation has reached the point where, on the island of Luzon, the demand for 'Lakatan' is being met by large commercial plantations producing for the export market, rather than by the small-scale farmers who traditionally supplied the local market. The big companies have succeeded where smallholders failed by using clean tissue culture planting material. In Taiwan, the spread of Fusarium wilt race 4 on Cavendish cultivars has been similarly brought under control by a massive use of tissue culture plants, coupled with wide-scale planting of resistant somaclonal variants.

To reach the smallholders, the plan is for some farmers to establish nurseries as a viable business. The nursery owners will buy *in vitro* plants that they will grow and harden off in plastic bags in the nurseries until they are ready to plant and sell to other smallholders. Because of the large quantities required, the NRMDCs will first send the small *in vitro* plantlets to private tissue culture laboratories, such as Lapanday Fruits Co., for multiplying on a large scale.

Because of the economies of scale that can be achieved by producers like Lapanday, the plantlets will be affordable for the smallholders. Each *in vitro* plant will cost less than 10 US cents and another 10 to 15 cents will go towards the cost of growing and hardening off. Even with the nursery owner's take, the planting materials will be less expensive than if they had been supplied directly as ready-to-plant materials by private laboratories.

Trials are also under way to try and devise the most appropriate production strategy for farmers. Plots in which the plants are uprooted every year and replaced with clean planting materials are compared with plots in which tissue culture plants are used the first year only and suckers are allowed to take over. Plots have been set up in areas of varying disease intensity to determine which strategy works best under a given disease pressure. In heavily infested areas, it may be necessary to replant every year, but in less disease ridden ones, it may not be essential.

Previous studies on the benefits of biotechnology to small-scale banana farmers conducted in East Africa have shown that farmers were very impressed by the monetary advantages of using tissue culture plants. They welcomed the higher yields and shorter production cycles. Small-scale farmers in Asia who might have been tempted to give up on bananas altogether should similarly welcome this chance to boost productivity and defend their livelihoods against spreading epidemics of disease.

Farmer Feng Ruihhao, from Guandong Province in China, is making a business of supplying disease-free plantlets *(A. Molina, INIBAP).*

The plan is for some farmers to establish nurseries as a viable business

INIBAP in brief

INIBAP's agenda is divided into four thematic areas:

– Conserving and managing diversity

– Using diversity for genetic improvement

– Supporting regional research and development

– Sharing information.

Progress in each area is summarised together with the activities of the thematic and regional networks for which INIBAP provides the secretariat.

Conserving and managing diversity

Central to our work on conserving and managing *Musa* diversity is the International *Musa* Germplasm Collection, managed by INIBAP at the INIBAP Transit Centre (ITC) in KULeuven* with the support of the Directorate General for Development Cooperation of Belgium. Funds from the Gatsby Charitable Foundation and the World Bank are being channeled into a programme to improve the conservation of accessions and also the representativeness of the collection. Other activities include the management of data on *Musa* accessions worldwide, research into viral diseases and the molecular and morphological characterization of the accessions.

Collecting

- The collection consists of 1168 accessions, including 20 accessions collected in Tanzania during 2001 and 7 accessions from a collecting trip to the Comoro Islands. An additional 5 somaclonal variants from a breeding programme in Cuba have been received.
- The results of a *Musa* diversity survey in Sabah and Sarawak were published at the end of 2003 with the University of Helsinki.
- A plan for an INIBAP-CARBAP-INERA team to collect plantain diversity in the Congo basin (as part of a Gatsby-funded conservation project) was postponed because of the political situation in the area.

Conservation

- Two partners, CIBE-ESPOL in Ecuador and Infruitech-Nitvoorbij in South Africa, were identified to help cryopreserve the collection. The technicians from Ecuador and South Africa received training at KULeuven in 2003. As of the end of 2003 a total of 159 accessions are in cryopreservation.
- Research into the cryopreservation protocol for proliferating meristems indicates that a preculture of 0.3-0.4 M sucrose is optimal for several banana genome groups ('Lady finger' (AAB), 'Williams' (AAA), 'Orishele' (AAB) and 'Cachaco' (ABB)). Experiments on the protocol using meristems from rooted *in vitro* plantlets of three cultivars ('Williams' (AAA), 'Figue famille' (AAB) and 'Mbwazirume' (AAA-h)) conclude that the PVS2 treatment should be extended from 20 to 30 minutes.
- Work on rejuvenation of the collection continued; 22% of the collection has been replaced in medium term storage. By the end of 2003, 180 accessions had reached the stage where they could be sent into the field for verification. A further 321 accessions are planted in the greenhouse. Agreements are being drawn up with five field genebanks (NARO, BPI, CARBAP, CIRAD and FHIA) to verify trueness-to-type.
- A seed conservation protocol for wild species is being developed in collaboration with UPM Malaysia.
- The installation of the data management system for the banana collection will be completed and fully functional in 2004. Information from paper

* See page 40 for the full name of acronyms and abbreviations.

records is currently being entered into the database.

- Leaf samples of 135 accessions were frozen and stored at –80˚C for the pilot DNA collection. The minimal number of replicates was set at 12. The next steps will consist of the lyophilization and long-term storage of leaf tissue at –20˚C.

Characterization

- The ploidy screening of accessions at the ITC entered its final phase in 2003. During the year, work was focused on the verification of ploidy in accessions that had been classified as mixoploid in previous analyses. In total, 61 accessions were analysed in 2003, taking the grand total to 1170 accessions analysed.
- The activities of the Global *Musa* Genomics Consortium and the initiation of the Generation Challenge programme for "Unlocking genetic diversity in crops for the resource-poor" have provided new impetus and resources for the molecular characterization of the ITC collection.
- *Musa balbisiana* is being characterized in a joint project between 9 partners (Australia: DPI; Austria: IAEA; Czech Republic: IEB; France: CIRAD; India: IIHR, NRCB; Mexico: CICY; Philippines: PBI; Thailand: CAB).
- Morphological characterizations are taking place as part of the rejuvenation effort at the ITC funded by USAID, the government of the Philippines, World Bank and Gatsby Foundation (see under "Conservation").

Dissemination

- A total of 551 accessions were distributed in 2003.
- The wording for the material transfer agreement (MTA) used in the distribution of FAO-designated germplasm was revised in line with the International Treaty on PGRFA. The new MTAs can be found on the INIBAP website.
- Virus indexing tests were completed for 70 accessions, of which 18 were found to be virus infected. Only 30 accessions remain in the collection that have not been virus-tested at least once.

Virus research

- PPRI is working on the production of antisera to the range of BSV isolates obtained from germplasm at the ITC.
- CIRAD is making an assessment of the risks of spreading BSV through disseminating *Musa* germplasm.
- Funds from the World Bank have allowed the resumption of virus therapy work, concentrating on cryotherapy and heat therapy. KULeuven and the University of Gembloux are collaborating on the project.

MGIS

- The MGIS database currently contains 5143 accessions, provided by 16 research institutions. There are 5143 passport data entries, 1650 agronomic evaluations, 1914 morpho-taxonomic descriptions, 300 evaluations to stress, 890 recorded shipments of material and 1010 photos.
- An on-line version of MGIS was released on the web in December 2003: http://mgis.grinfo.net. Cross queries are possible to get a list of accessions. Botanic classifications based on morphological characters may now be shown together with ploidy and molecular characterization by using RFLPs.
- Plans for upgrading the MGIS database are being developed with the aims of improving the capacity for data analysis and querying. Users' requirements and technological capacity were studied. The development of a specific module to record the results of germplasm screening against nematodes is under consideration. The database will be further developed during 2004 to store molecular characterization data.
- A MGIS workshop to train germplasm curators from Southeast Asia and the Pacific took place in December 2003, hosted by MARDI. Newcomers from Cambodia, China, Bangladesh and Solomon Islands participated.
- An internship supported by the Quebec Ministry of International Relations provided the opportunity to review the published literature on the distribution of wild species of *Musa* in Asia. With the support of *Musa* taxonomists, the resulting information was plotted on a series of maps with DIVA software.
- The Generation Challenge Programme on 'unlocking the genetic diversity of crops for the resource poor', officially launched at the end of 2003, has chosen *Musa* as one of 11 priority crops and has identified MGIS as a model system for storing accession-level information.

Using diversity for genetic improvement

INIBAP's support to crop improvement focuses on broadening the genetic base of materials available to banana and plantain breeders around the world, facilitating interactions between breeders, encouraging interactions with specialists in pests and diseases, and helping breeders to achieve the widest possible evaluation and uptake of the improved materials resulting from their work. Molecular techniques are becoming increasingly important in understanding the diversity in the *Musa* genome, how it functions, and how it can be used in crop improvement. Much of this agenda is pursued through consortia for which INIBAP provides the secretariat (see below). The recently-launched Generation Challenge Programme is expected to provide a further impetus to research in this area and the Global *Musa* Genomics Consortium has already played a key role in bringing together research groups working on *Musa* to develop a coherent response to this new opportunity.

International *Musa* Testing Programme

Phase III varieties and hybrids have been distributed to more than 50 institutions around the world and are being evaluated in research stations and also in farmers' fields. The participating institutions come from Australia, Bangladesh, Burundi, Cameroon, China, Colombia, Costa Rica, Côte d'Ivoire, Dominican Republic, Ethiopia, Haiti, Honduras, India, Indonesia, Malaysia, Mexico, Nicaragua, Peru, Philippines, Rwanda, South Africa, Sri Lanka, Uganda, Venezuela, Vietnam.

- All the trials are now planted and all partners have started evaluating performance. The first data have been received at INIBAP in Montpellier to be analysed and integrated into a centralized database.
- The Phase III evaluations are also contributing new knowledge on plant-pathogen interactions.

Support to breeding programmes

This activity currently focuses on strengthening FHIA's banana breeding programme as a source of improved varieties for use in international development efforts and has been supported by USAID. FHIA continues to develop elite, high-yielding hybrids with improved pest and disease resistance. New capacities in molecular biology are also being developed to help in the selection of parents or new hybrids.

Table 1. Number of hybrid plants from FHIA's segregating populations.

Crosses	Number of plants
AVP-67 x SH-2989	7
AVP-67 x Calculta 4	17
FHIA-20 x SH-3648	1
FHIA-21 x SH-3648	9
Pelipita x SH-3648	222
Pisang awak x SH-3648	3
SH-3648 x SH-2989	21
SH-3648 x SH-3142	93
SH-3648 x SH-3362	204
Highgate x SH-2989	2
Highgate x SH-3142	13
Highgate x SH-3437	6

- Ten of the 20 planned crosses have been concluded. In 2003 field evaluation of more than 600 hybrid segregant plants (see table 1) was initiated.
- FHIA's banana breeder received additional training in the use of molecular tools.
- The FHIA field collection is being replanted.
- Two segregating populations, supplied by CIRAD, have been planted in the field at CORBANA, Costa Rica with the aim of isolating genetic traits for fruit quality.

Developing improved East African highland banana varieties using biotechnology

(For more information see the article "Gene power fuels an African agricultural revolution" on page 14.)

East African highland bananas (EAHB) provide the staple food and main source of income in many upland areas in East and Central Africa but have received comparatively little attention from the international research community. This work, supported by the Ugandan Government, USAID, the Belgian Government, and the Rockefeller Foundation, aims to build Uganda's national capacity to use the current tools of biotechnology to develop high-yielding, pest- and disease-resistant varieties of this crop.

Partners, by country: Belgium: KULeuven; France: CIRAD; South Africa: FABI-University; Uganda: IITA, Makerere University, NARO; UK: JIC.

- Cell suspensions are now available for the cultivar 'Ndizi' (AAB).
- Embryogenic cultures have also been obtained by using the male flowers from 6 EAHB cultivars.
- Two gene transfer systems have been shown to be effective in a wide range of banana cultivars. PCR analysis confirmed that the two rice chitinase genes (rcc2 and rcg3) were integrated in the banana genome.
- Among the suitable genes to control nematodes, lectin-, lectin-related- or RIP-genes have been selected and transfered into one transgenic *Arabidopsis thaliana* line. Both the lectins themselves and the lectin-transformed bacteria are being tested for their toxicity to nematodes.
- Two synthetic proteinase inhibitors (E-64 and PMSF) were used to evaluate the proteolytic activity of weevil midgut extracts. Both inhibitors had an effect, confirming that cysteine and serine proteinases are present in the banana weevil gut. The cysteine proteinase inhibitor E-64 had the stronger inhibitory effect.
- Weevil larvae that were fed on banana disks infiltrated with purified cystatins showed reduced development. This experiment demonstrated the potential of cystatins to block weevil development.

- *Bt* toxins are being tested on banana corms for their potential to control the banana weevil. One of the toxins, CryIIICa1, was effective according to larval weight loss and mortality figures. Future plans include testing *Bt* strains isolated from Ugandan soils.
- The molecular biology and genetic engineering laboratories at the NARO research station in Kawanda were officially opened by the President of Uganda.
- At KULeuven, new promoters are being developed to enhance the efficiency of the gene constructs transferred.

Developing genetic transformation protocols

With funds from DGDC, INIBAP pursues studies to refine the protocols for developing and storing starting materials for genetic transformation and for optimizing the process of transformation. The research takes place in the Laboratory of Tropical Crop Improvement at KULeuven.

- Nineteen high quality embryogenic cell suspensions were established.
- Ten cell lines were recovered from cryopreservation for transformation experiments.
- The cryopreserved collection consists of 1 347 tubes, of which 407 were confirmed to be "safely stored" after thawing of representative samples.
- The influence of a broad spectrum of plant growth regulators on the development of banana shoot tips was explored.
- A novel tagging vector was developed with the aim of identifying promoters with specific expression patterns in the banana genome. More than 19 000 transgenic colonies were evaluated and several promoter tags have been cloned.
- SAGE was performed on cDNA obtained from infected and non-infected leaves of Sigatoka-resistant banana varieties. 10 196 tags were sequenced.
- Xylose was shown to be unsuitable as an agent for selecting transformed banana plants because of its negative affect on regeneration frequency.
- Efforts are being focused on increasing transformation frequency in meristematic cultures. Antiblackening agents and meristem age were examined systematically.

PRO*MUSA*

The Global Programme for *Musa* Improvement, PRO*MUSA*, brings together more than 100 researchers to focus on the smallholder crop. Working groups are devoted to Sigatoka, Fusarium wilt, Nematology, Weevils, Virology and Genetic Improvement. INIBAP provides the secretariat.

- During the 2nd meeting of the PRO*MUSA* breeders group held in Coimbatore, India, in June, an initiative to develop closer collaboration between breeders was launched (see below). The study of the 'balbisiana' genome was designated a priority for immediate research. A plan for the genetic improvement of banana and plantain in Asia and Pacific was drafted.
- The 2nd International symposium on Fusarium wilt took place in Salvador de Bahia, Brazil in September, followed by a meeting of the PRO*MUSA* Fusarium working group.

An initiative to develop closer collaboration between banana breeders has resulted in the launching of a breeders' consortium. The aims of the group include the development of resources, knowledge and tools for sharing among *Musa* breeders, joint exploration for new breeding materials and support for the wider utilization and conservation of *Musa* biodiversity for the purposes of improving the smallholder crop. The members of the new Consortium intend to maximize the use of cytogentic and molecular tools becoming available and hope to work closely with the Global *Musa* Genomics Consortium. INIBAP will perform a secretariat function. A management committee will be set up and membership formalized in 2004.

Global *Musa* Genomics Consortium

This Consortium brings together expertise from 28 public-funded institutions in 15 countries. As well as providing close collaboration, the Consortium enables research resources to be shared, including sequence data and enabling technologies. The sequence produced by the Consortium will be placed in the public domain and any new varieties will be made freely available to smallholder farmers. The overall strategy of the Consortium is to adopt a step-wise approach, focusing on comparative genomics and targeting gene discovery. INIBAP provides the secretariat. Funding is provided by the members through individual projects.

Partners, by country: Australia: DPI, QUT, University of Queensland; Austria: FAO/IAEA; Belgium: KULeuven, UCL, University of Gent; University of Liege, University of Gembloux; Brazil: CENARGEN/EMBRAPA, Universidade Catolica de Brasilia; Czech Republic: IEB; France: CIRAD, INIBAP; Germany: MIPS/GSF; India: IIHR; Japan: NIAS; Malaysia: UM; Mexico: CICY, CINVESTAV; Nigeria: IITA; Uganda; IITA-ESARC; UK; University of Leicester; USA: Arizona State University, NSF, TIGR, University of Georgia; University of Minnesota.

- An agreement has been made with Syngenta to obtain a set of ESTs. Sequences were analysed by MIPS/GSF and made available to other members through an established letter of agreement.
- Segregating populations, mutants and transgenic plants are being developed and will be made available to member institutions.
- The Consortium has also started developing a bio-informatics component.

Musa *Genomics Resource Centre*

The *Musa* Genomics Resources Centre (MGRC) administered by INIBAP was established at the IEB in the Czech Republic and is already serving members of the Consortium. The aim of the MGRC is to provide DNA libraries, individual DNA clones, markers for molecular cytogenetics and high-density colony filters to the members of the Consortium. Three BAC libraries are now available through the MGRC as 384 or 96 well plates or as high-density colony filters and, exceptionally, as single clones (see table 2). A growing collection of repetitive DNA clones is also being maintained and characterized by copy number, genomic distribution in *Musa acuminata* and *Musa balbisiana*, and similarity to known DNA sequences. Cytogenetic markers available for distribution include those for 5S and 45S ribosomal RNA loci. New cytogenetic markers based on BAC clones isolated from genomic libraries are being developed.

International *Mycosphaerella* Genomics Consortium

Partners, by country: Brazil: EMBRAPA; Cuba: IBP; France: CIRAD; Mexico: CICY; Netherlands: PRI; Switzerland: ETH; and USA: BTI.

The research community working on *Mycosphaerella fijiensis*, including seven laboratories worldwide, joined forces with researchers working on *Mcosphaerella graminicola* to form the International *Mycosphaerella* Genomics Consortium in Mexico in August 2003. *Mycosphaerella graminicola*, which attacks wheat, has been extensively studied at a molecular level. The findings will assist greatly the efforts to analyse the *M. fijiensis* genome.

Table 2. Features of the BAC libraries available through the MGRC.

Name	Genotype	No. of clones	Average insert size	Genomic coverage	Restriction site	Authors
C4BAM	Calcutta 4	17280	110kb	3x	*Bam*HI	A.C. James and Q. Tao
MA4	Calcutta 4	55296	100kb	9x	*Hind*III	A. Vilarinhos and P. Piffanelli
MBP	Pisang Klutuk Wulung	36864	135kb	9x	*Hind*III	J. Safár and P. Piffanelli

INIBAP around the world

As a "network of networks", INIBAP's agenda is, to a considerable extent, determined by the partners who own those networks. Thus, each of the regional networks for which INIBAP provides the secretariat – *MUSA*LAC, BAPNET, BARNESA and *MUSA*CO – has a steering committee that meets regularly to identify priorities. In addition, INIBAP is implementing a series of projects with partners in each region.

Inter-regional projects

Farmer participatory evaluation and dissemination of improved *Musa* germplasm

(For more information see the article "Improved hybrids up for adoption" on page 10.)

Donor: CFC

Partners, by country: Democratic Republic of Congo: INERA ; Ecuador: FUNDAGRO; France: CIRAD; Haiti: IICA; Guinea: IRAG; Honduras: FHIA; Nicaragua: UNAN-LEON; Uganda: NARO

Aim: To sustainably increase banana production by bringing improved varieties into farmers' fields for evaluation and improving dissemination systems

Activities in 2003:
- Plants were established in demonstration plots and farmers are in the process of selecting varieties for growing.
- 778 farmers established small multiplication plots with over 30 000 plants.
- Farmers were trained in rapid multiplication techniques and improved production and post-harvest technologies.
- 800 participants took part in 21 evaluation events and data on growth, yield and palatability are being gathered from the demonstration plots.

Increasing productivity and market opportunities for banana and plantain

(For more information see the article "Improved hybrids up for adoption" on page 10.)

Donor: USAID TARGET

Partners, by country: Cameroon: CARBAP, Cameroon Gatsby Trust; Ghana: CSIR, WV Ghana; Mozambique: INIA, AFRICARE, CARE, Ministry of Works, UEM, *Casa do Gaiatus*; Tanzania: ADRA, ARDI, FAIDA. This work is jointly implemented by IITA and INIBAP

Aims: To put in place a system to ensure a continuous supply of planting material, to provide training in improved production and raise rural income through community-based activities

Activities in 2003:
- Project coordinating committees have been established in all countries and participating farmers have been identified.
- National collaborators have been trained in the management of tissue culture plantlets and planting material has been weaned and hardened with low-level plant losses.

- Partner organizations in Ghana and Cameroon distributed to 1000 farmers 16 000 *in vitro* plantlets previously hardened off.
- Partners in Mozambique and Tanzania hardened off 16 000 *in vitro* plantlets in preparation for distribution to farmers.
- Preliminary studies on marketing have been undertaken in three of the four countries.

Latin America and the Caribbean

Organic banana production in Bolivia

(For more information see the article "The highs and lows of organic bananas in South America" on page 4.)

Donor: CICAD-OAS

Partners: VIMDESALT, Banana Farmer Associations

Aim: To rehabilitate banana production in the Alto Beni region of Bolivia through the use of strengthened farmer associations and organic production for urban and international markets

Activities in 2003:

- Organic certification by Skal International has been procured for ten farmer associations.
- Improved production technologies continue to be adopted.
- A commercialization centre equipped with four ripening chambers has been established.
- Organic bananas are being sold to the general market and for school breakfasts in La Paz.

Training and research on black Sigatoka management for plantain

Donor: FONTAGRO

Partners, by country: Brazil: EMBRAPA-CNPMF; Colombia: CORPOICA; Costa Rica: CATIE, CORBANA; Dominican Republic: CEDAF; Mexico: INIFAP; Nicaragua: UNAN-LEON; Panama: IDIAP and Venezuela: INIA

Aims: To develop integrated management strategies against black Sigatoka and to transfer technology, and distribute and evaluate disease-resistant hybrids

Activities in 2003:

- Information has been collected on the current status of black Sigatoka in nine countries in South America.
- A total of 23 MSc and 9 BSc theses have been completed.
- A final project meeting took place in July. Results of the research by the different partners were presented and will be published.

Development of plantain cultivars resistant to black Sigatoka for Latin America

Donor: FONTAGRO

Partners, by country: Colombia: CIB-UNALMED; Costa Rica: CORBANA, CATIE, UTolima-CATIE Agreement; and Mexico: CINVESTAV

Aims: To improve plantain production in Latin America by using genetic transformation methods to develop new resistant cultivars and a fast evaluation system for detecting black Sigatoka resistance under controlled conditions

Activities in 2003:

- A refined and reliable protocol has been developed to obtain embryogenic cell suspensions.
- Banana cell suspensions have been established and constructs for transformation are being developed.
- Vectors have been obtained to conduct genetic transformation.
- The protocols for the evaluation of the transgenic plants are being standardized.

*MUSA*LAC activities, meetings and training

The Plantain and Banana Research and Development Network for Latin America and the Caribbean (*MUSA*LAC) operates under the auspices of the *Foro Regional de Investigación y Desarrollo Tecnológico Agropecuario para America Latina y el Caribe* and is coordinated by INIBAP in Costa Rica.

- The *MUSA*LAC Steering Committee meeting was attended by 34 participants from 14 countries.
- An international workshop, sponsored by the private sector, on "Banana root systems: towards a better understanding for productive management" was co-organized with CORBANA in November. A total of 120 participants attended.
- Six plantain production courses were organized in Aruba, Bolivia, Colombia, Dominican Republic and Ecuador.
- 100 participants from throughout the region were trained in the management of black Sigatoka, nematodes and other pests and diseases in Ecuador. The event was organized in collaboration with FUNDAGRO, ESPOL from Ecuador and *MUSA*LAC.
- A workshop, co-organized with IDIAF, on the application of statistical techniques in *Musa* research allowed 35 participants to be trained in the Dominican Republic.

Asia and the Pacific

National repository, multiplication and dissemination centres

(*For more information see the article "Returning home to Asia" on page 20.)*

Donors: European Union, the Philippines and Taiwan Governments

Partners, by country: Bangladesh: BARI; Cambodia: CARDI; China: SCAU, GAAS, CATAS; Fiji:SPC; India: NRCB; Indonesia: ICHORD; Malaysia: MARDI;

Myanmar: MAS; Papua New Guinea: NARI; Philippines: BPI, IPB; Sri Lanka: HORDI; Taiwan: TBRI; Thailand: HRI and Vietnam: VASI

Aims: To enable countries to supply clean planting material of improved and local varieties to researchers and farmers on a large scale

Activities in 2003:
- Plants of improved varieties, supplied by ITC, have been established in insect-proof nurseries in all countries to serve as foundation stocks for mass tissue culture production.
- Performance trials have taken place on-station and in farmers' fields.
- In the Philippines a number of institutes have received planting materials from the NRMDCs for further multiplication and distribution to farmers.
- Philippine farmers have been trained in improved production techniques through support from DA-BAR.
- An IPM training seminar on virus-free planting materials was carried out in Indonesia, Philippines, Malaysia and Vietnam for the personnel of NRMDCs. The training was co-organized and co-funded by the FFTC in Taiwan.

Nematode studies

Donor: VVOB

Partners, by country: India: NRCB; Philippines: IPB

Aims: To investigate sources of nematode resistance and build capacity in India and the Philippines to conduct nematological studies

Activities in 2003:
- The research teams are established in both countries and in the Philippines training in basic nematological techniques has taken place.
- Four PhD students have been registered; two at KULeuven and two at Tamil Nadu Agricultural University. Work programmes are developed.
- A regional training course on "Enhancing capacity for nematode management in small-scale banana cropping systems" took place in the Philippines in December.

BAPNET activities, meetings and training

The Banana Asia and Pacific Network (BAPNET) operates under the auspices of the Asia Pacific Association of Agricultural Research Institutes and is coordinated by INIBAP in the Philippines.

- The Steering Committee meeting was held in Indonesia in October.
- An MGIS training course took place in Malaysia in December.
- A number of training events on nursery and field management of *in vitro* propagated plants took place in the Philippines.

Eastern and Southern Africa

Utilization of banana-based biodiversity to improve livelihoods

Donor: IDRC

Partners, by country: Tanzania: ARDI, Farmer Associations from Bisheshe, Chanika and Ibwera, FADECO; Uganda: Farmers Associations from Bushenyi and Masaka, NARO, Makerere University, Ssemwanga Center for Food and Agriculture, VI Agro-forestry Project, Uganda Biodiversity Network

Aims: To strengthen banana-based biodiversity conservation strategies by using diversity products as a means to improve livelihoods

Activities in 2003:
- A planning workshop was held in Kampala in July. Three main guiding principles were identified as poverty alleviation, conservation of the natural resource base and stakeholders participation.
- Consultation meetings at the benchmark sites were held to streamline the management structures of the Farmer Associations and to come up with a sustainable development plan in relation to the objectives of the project.
- Farmers' support for the project is high, with particular interest being shown in banana-based biodiversity and the development of new products with an identified market.

Farmer-participatory testing of integrated pest management technologies

Donor: DFID

Partners, by country: Kenya: KARI; Tanzania: ARDI; Uganda: NARO

Aims: To test IPM options in various combinations in a range of agro-ecological and socio-economic settings, and to train farmers so that they can use IPM approaches independently in their farming systems

Activities in 2003:
- Data gathering and analysis were completed.
- Extension materials were developed, translated into local languages and distributed to farmers.
- A total of 255 farmers took part in the project and a farmer association was formed in each country. Ugandan farmers also visited NARO research station and Kenyan farmers visited Ugandan sites.
- A final reporting workshop was held in December and the papers will be published in a special edition of the African Crop Science Journal.

Assessing impacts on livelihoods

Donor: IFAD, Rockefeller Foundation, USAID

Partners, by country: Tanzania: ARDI, Sokoine University; Uganda: IITA, Makerere University, NARO; USA: IFPRI

Aims: To examine the sociological and economic impacts of improved varieties of banana on the livelihoods of smallholder farmers and to build capacity in NARS and universities to carry out multi-

disciplinary impact studies using the sustainable livelihoods approach

Activities in 2003:
- A sociological research team has been formed, including three MA students and one PhD student and a senior advisor.
- The household survey being carried out by the economics team is well advanced.
- A Sustainable Livelihoods training course for all African-based researchers in the project, led by a facilitator supported by the IPGRI Innovation Fund took place in Kampala in July.
- A research planning meeting took place in October in Bukoba, Tanzania, and a project management meeting for the steering group, researchers and coordinators took place the same month in Kampala, Uganda.
- An agreement to ensure that the data are shared between partners has been drafted and signed by the directors of all the participating institutions.

Root system growth and disease in bananas and enset

Donor: VVOB

Partners, by country: Ethiopia: SARI; Uganda: NARO, University of Makerere

Aims: To understand the variability in root growth and shoot-root relationships in highland banana genotypes and assess the influence of pests and diseases on root and shoot growth of enset and banana genotypes

Activities in 2003:
- MSc students from the University of Makerere are undertaking projects on root system research.
- Enset publications are being compiled and entered into a database that is similar to *MUSA*LIT.

Baseline information project

Donor: Rockefeller Foundation

Partners, by country: NARS in Kenya, Tanzania, Uganda, Burundi, Rwanda and Malawi

Aims: To gather information on banana production in a geographically referenced database for use as a research and developing planning tool

Activities in 2003:
- Data collection and analysis was completed at the end of 2003.

BARNESA activities, meetings and training

The Banana Research Network for Eastern and Southern Africa (BARNESA) operates under the auspices of the Association for Strengthening Agricultural Research in Eastern and Central Africa with funding from the EU. It is coordinated by INIBAP in Uganda.
- A Steering Committee meeting took place in December in Kenya and a 'logframe' defining priority activities was developed.

West and Central Africa

Improving peri-urban production

Donor: Government of France

Partners, by country: Benin: INRAB, CARDER; Ghana: CSIR, University of Ghana

Aims: To evaluate disease resistant/tolerant and high-yielding plantain and banana hybrids in periurban zones and to train farmers in rapid multiplication techniques

Activities in 2003:
- Evaluation trials are ongoing.
- Farmers are being trained in rapid multiplication techniques.

Evaluating plantain production at high planting densities

Donor: INIBAP funds

Partners, by country: Cameroon: CARBAP, Côte d'Ivoire: CNRA

Aims: To optimize the high-density planting techniques that West African farmers and researchers learned on a CTA and INIBAP-sponsored visit to the Dominican Republic and Costa Rica in 2001

Activities in 2003:
- Trials are ongoing.

Nematode studies in Cameroon

Donors: CARBAP and VVOB

Partners: CARBAP, IITA

Aims: To investigate the importance of the nematode, *Pratylenchus goodeyi,* in banana production systems in the western and north-western provinces of Cameroon

Activities in 2003:
- Trials are established to investigate the 1) effect of *P. goodeyi* on plant growth and yield of several *Musa* cultivars, 2) pathogenicity and diversity of *P. goodeyi,* 3) effect of cropping systems and management practices on the population dynamics of *P. goodeyi*, 4) host suitability of non-*Musa* crops for *P. goodeyi.*

*MUSA*CO activities, meetings and training

The *Musa* Research Network for West and Central Africa (*MUSA*CO) operates under the auspices of the West and Central African Council for Agricultural Research and Development. It is coordinated by INIBAP in Cameroon.
- A Steering Committee meeting was held in Guinea Conakry. Concept notes were elaborated for information/documentation activities, postharvest technologies, and banana and plantain production systems.
- A training course on germplasm evaluation techniques took place for Committee members with expertise being provided by CIRAD.
- A training course for *MUSA*CO members on post-laboratory handling of tissue culture plantlets and rapid multiplication of planting materials took place in Cameroon.

Sharing information

All INIBAP staff play a role in communicating research findings and new technical information to scientists and farmers, as well as in raising the public's awareness of banana as a staple food and the necessity for research and development. The following summary presents the activities of INIBAP's information and communications group in 2003.

The virtual library

- *MUSA*LIT now includes 8393 bibliographic abstracts in 3 languages.
- 34% of the references in the *MUSA*LIT database are linked to their full text documents and more than 800 INIBAP publications are now electronically available though INIBAP's website and on *Musa*Doc 2003.
- 800 new records were added to *MUSA*LIT. BRIS contains almost 900 records (including 37 new records) on researchers.
- 850 information requests were processed in 2003.
- The trilingual *Musa* thesaurus is now linked to the bibliographic database.
- The *MUSA*DOC 2003 CD-Rom was published in October and distributed to 1500 users.

INIBAP on the internet

- The research and general information pages on the INIBAP web site are being redesigned.
- The home for the Global *Musa* Genomics Consortium is being updated and a link to the *Musa* Genomic Resource Centre created so that members can access information on available genomics resources.
- Average daily number of visits has increased nearly 50% to 564.
- 42 200 Mb of publications were downloaded in 27 400 transactions.

Publications

- INFO*MUSA* and the PRO*MUSA* newsletter (now called PRO*MUS*@) were redesigned. PRO*MUS*@ is distributed in electronic form and upon request in hard copy.
- Two trilingual technical guidelines (No. 7 and 8), entitled "Global evaluation of *Musa* germplasm for resistance to Fusarium wilt, *Mycosphaerella* leaf spot diseases and nematodes" and "Banana and plantain embryogenic cell suspensions", were produced.
- The proceedings of the 2002 international workshop on *Mycosphaerella* leaf spot diseases, entitled "*Mycosphaerella* leaf spot diseases of bananas: present status and outlook", was published.
- A booklet including the programme and abstracts of the 2nd International symposium on Fusarium wilt on banana was produced.

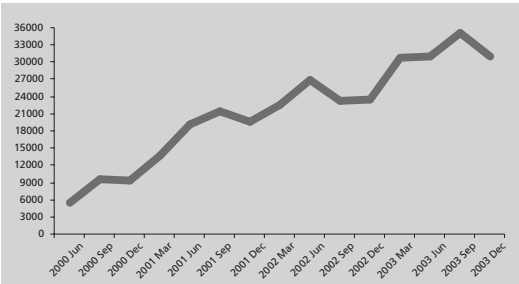
Raising awareness

- INIBAP contributed, together with IDRC and Oxfam Canada, to a booklet, targeted at Canadian high schools and general public, to explain where the banana comes from.
- A feature article on the threats to the banana was published in the British science magazine *New Scientist,* with inputs from INIBAP. Its impact worldwide was resounding, with articles published in national and local papers in more than 50 countries.
- INIBAP has helped develop the banana exhibit at the Eden project, which now features a genuine banana beer boat crafted in Uganda.

Regional information networks

- A survey of 90 *Musa* information centres in Africa was initiated to find out about their information resources and needs.
- A documentation centre has been set up in CARBAP, Cameroon. A regional bibliographic database is established and a question and answer service is now available.
- Information partnerships are being developed with various African networks, including WECARD, ASARECA, SACCAR and FARA.
- The first issue of the African newsletter, *MUSA*frica, jointly produced by IITA, CARBAP and INIBAP, was published in August in French and English.
- Two issues of the RISBAP Newsletter were published.
- The African and Asia/Pacific information networks contributed to *MUSA*LIT database almost 100 bibliographic records.

Visits to the Inibap Web site since its launching in April 2000



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Arnaud E. & *P. Pollefeys.* Preliminary study on the distribution of the wild species in southeast Asia. MARDI, Serdang, Malaysia, December 2003.

Belalcázar Carvajal S. Seminario sobre el manejo del "moko" del banano y el plátano: Sintomatología, rango de hospedantes y métodos de manejo del "moko". ICA, Armenia, Quindio, Colombia, 23 April 2003.

Belalcázar Carvajal S. Presentations made at the Curso regional sobre siembra y explotación del cultivo del plátano, Quevedo, Ecuador, 17-18 June 2003:
– Cultivares, ecofisiología, morfología y ciclo vegetativo de la planta de plátano.
– Semilla: producción, selección por tamaño y tratamiento.
– Sistemas de siembra y uso y manejo de altas densidades de siembra.
– Siembra: profundidad y época.
– Manejo agronómico: deshije, deshoje, desmane y destronque.
– Nutrición y fertilización del cultivo del plátano.
– Plagas y enfermedades: importancia económica y manejo.
– Cosecha y manejo de poscosecha.

Belalcázar Carvajal S. Presentations made at the Seminario sobre nutrición y fertilización del cultivo del plátano, Caicedonia, Valle del Cauca, Colombia, 23 July 2003:
– Cultivares, ecofisiología y morfología y ciclo vegetativo de la planta de plátano.
– Nutrición y fertilización de la planta de plátano: dosis, épocas y formar de fertilización.
– Fertilización en el sistema de altas densidades de siembra.

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– Producción de plátano en altas densidades de siembra y su efecto en el manejo de la Sigatoka negra.
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del plátano, Armenia, Quindio, Colombia, 26 November 2003:
– Ecofisiología del cultivo del plátano.
– Morfología y ciclo vegetativo de la planta de plátano.
– Nutrición y fertilización del cultivo del plátano: acumulación de biomasa, extracción de elementos nutritivos, calibración de los análisis de suelos, respuesta de la planta de plátano a la fertilización, forma y época de aplicación de los fertilizantes.

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Blomme G. Project outlines: Farmer-participatory testing of banana IPM options for sustainable banana production in eastern Africa. The IPM end-of-project workshop. Ridar Hotel, Seeta, Uganda, 8-9 December 2003.

Blomme G. Project overview: Farmer-participatory testing of banana IPM options for sustainable banana production in eastern Africa. BARNESA stakeholders meeting. Nairobi, Kenya, December 2003.

Molina A. Opportunities and challenges in banana production in Asia and the Pacific. IRRI-Thursday Seminar, Los Baños, Philippines.

Molina A. The role of the national banana repository centers in enhancing the banana industry. Seminar-workshop on Enhancing banana production in Malaysia, MARDI, Malaysia.

Molina A. The Role of national repository centers and clean foundation stocks in rehabilitating the banana industry in the Philippines. Seminar-workshop on the Rehabilitation of small-scale banana industry in the Philippines PCARRD, Los Baños, Philippines.

Molina A. Advances in Banana R&D: Relevance in alleviating banana production constraints in Hainan, China. CATAS, Hainan, China.

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Pocasangre L.E. Nuevas estrategias para el manejo de nematodos en Musaceas. Taller internacional de manejo convencional y alternativo de Sigatoka negra nematodos y otras plagas. Guayaquil, Ecuador, 11-13 August 2003.

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Pocasangre L.E. Current status of Fusarium wilt on Gros Michel in smallholdings in Costa Rica. 2nd International symposium on Fusarium wilt on bananas. Salvador de Bahia, Brazil, 22-26 September 2003.

Roux N. Towards a *Mycosphaerella* Genomics Initiative. 1st *Mycosphaerella* Genomics Consortium meeting, CICY, Merida, Mexico, 18-20 August 2003.

Van den Bergh I. Host-plant response of Vietnamese bananas (*Musa* spp.) to plant-parasitic nematodes 34th Anniversary and Annual Scientific Conference of the Pest Management Council of the Philippines, Cebu, Philippines, 8 May 2003.

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Van den Bergh I. Field management of *in-vitro* propagated bananas. Training: Field Management of Bananas. Philippine Council for Agricultural Resources R&D (PCARRD), Los Baños, Philippines, 8-9 July 2003.

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– Why use tissue-cultured planting materials?
– Nursery management of *in-vitro* propagated bananas.
– Field management of *in-vitro* propagated bananas.

Van den Bergh I. Presentations made at the Seminar-workshop on tissue culture capacities for the production of disease-free banana plantlets. Indonesian Center for Horticultural Research and Development (ICHORD), Jakarta, Indonesia, 9-10 October 2003:
– The national repository, multiplication and distribution centers: their role in the banana rehabilitation programme.
– Why use tissue-cultured planting materials?
– Nursery management of *in vitro* propagated bananas.
– Field management of *in vitro* propagated bananas.

Van den Bergh I. Presentations at the Training workshop: enhancing capacity for nematode management in *Musa*. Institute of Plant Breeding (IPB/UPLB), Los Baños, Philippines, 1-5 December 2003:
– Culturing of *Musa* nematodes.
– Assessment of host-plant reaction of *Musa* to nematodes.
– Networking on *Musa* nematode R&D.

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Financial Highlights

Revenue

	Unrestricted	Restricted	Total
Australia	108		108
Belgium	251	1 084	1 335
Canada	423		423
European Union		687	687
France	164	17	181
India	25		25
Netherlands	75		75
Philippines	7	46	53
Quebec		30	30
South Africa	30		30
Thailand	3		3
Uganda		473	473
United Kingdom		167	167
USA	77	235	312
CATIE		26	26
CDC		207	207
CFC		413	413
CIMMYT (Challenge Programme)		14	14
CIRAD		29	29
CTA		69	69
FFTC		7	7
Gatsby Foundation		264	264
IBRD	264		264
IDRC		71	71
IFAD		15	15
KUL		16	16
OAS		798	798
Rockefeller Foundation		99	99
TBRI		2	2
VVOB		242	242
Other income	(151)		(151)
Total Revenues	**1 276**	**5 010**	**6 286**

Expenditures

	Unrestricted	Restricted	Total
Research Programme	1 361	5 010	6 371
General administration	291		291
Total Expenditures	**1 652**	**5 010**	**6 662**
Recovery of Indirect Costs	(480)		(480)
Total	**1 172**	**5 010**	**6 182**

As at December 31, 2003 - US$000.

Staff List 2003

	Name	Position	Nationality	Joined	Stationed
E.A.	Frison*	Director	Belgium	01-10-95	Montpellier
R.	Markham	Director	UK	01-07-03	Montpellier
A.	Akokulya	Driver/messenger	Uganda	01-01-03	Uganda
E.	Akyeampong	Regional Coordinator WCA	Ghana	01-06-97	Cameroon
E.	Arnaud	Officer in charge of MGIS	France	01-10-89	Montpellier
T.	Aourai	Accounting Assistant	UK	01-07-03	Montpellier
S.	Belalcázar	Honorary Research Fellow	Colombia	01-04-02	Costa Rica
G.	Blomme	Associate Scientist, Assistant to Regional Coordinator	Belgium	01-01-00	Uganda
R.	Bogaerts	Technician	Belgium	12-02-88	ITC, Belgium
G.	Boussou	Info/Doc Specialist	France	07-09-00	Montpellier
A.	Causse	Programme Assistant	France	22-11-99	Montpellier
H.	Doco	Info/Com Specialist, Webmaster	France	15-09-98	Montpellier
C.	Eledu	GIS Expert	Uganda	01-06-00	Uganda
L.	Er-Rachiq	Assistant Documentalist	France	19-08-02	Montpellier
J.V.	Escalant	Senior Scientist, Coordinator *Musa* Genetic Improvement	France	01-04-99	Montpellier
S.	Faure	Senior Programme Assistant	UK	01-06-88	Montpellier
L.	Fauveau	Website specialist, Consultant	France	03-11-03	Montpellier
E.	Gonnord	Accountant	France	17-08-98	Montpellier
K.	Jacobsen	Associate Scientist, *Musa* Technology Transfer	Belgium	01-05-01	Cameroon
J.	Kamulindwa	Administrator of the Ugandan Biotechnology Project	Uganda	03-05-01	Uganda
D.	Karamura	*Musa* Germplasm Specialist	Uganda	01-01-00	Uganda
E.	Karamura	Regional Coordinator ESA	Uganda	01-04-97	Uganda
E.	Kempenaers	Research Technician	Belgium	15-10-90	ITC, Belgium
K.	Lehrer	Programme Assistant	USA	06-01-03	Montpellier
C.	Lusty	Impact Assessment and PA Specialist	UK	05-06-00	Montpellier
S.B.	Lwasa	Programme Assistant	Uganda	01-08-97	Uganda
M.A.	Maghuyop	Technical Assistant	Philippines	01-07-00	Philippines
H.	Mbuga	Accounting Assistant	Uganda	15-04-02	Uganda
B.	Metoh	Programme Assistant	Cameroon	07-01-03	Cameroon
T.	Moens	Associate Scientist, Nematology	Belgium	01-06-98	Costa Rica
A.B.	Molina	Regional Coordinator ASP	Philippines	20-02-98	Philippines
A.	Nkakwa Attey	Supervisor, Plantain Technology Transfer Project	Cameroon	01-11-02	Cameroon
D.	Peden*	Intern – Impact Assessment / On-farm conservation	Canada	22-05-03	Uganda
C.	Picq	Coordinator, Information/Communication	France	01-04-87	Montpellier
L.	Pocasangre	Associate Scientist, *Musa* Technology Transfer	Honduras	01-07-00	Costa Rica
P.	Pollefeys*	Intern - MGIS	Canada	15-05-03	Montpellier
G.	Ponsioen	Info/Doc Specialist	Netherlands	12-04-99	Montpellier
V.	Roa	Programme Assistant	Philippines	01-01-91	Philippines
F.	Rosales	Regional Coordinator LAC	Honduras	01-04-97	Costa Rica
N.	Roux	Scientist, Coordinator *Musa* Genomics and Genetic Resources	Belgium	26-05-03	Montpellier
M.	Ruas	Database Manager	France	28-02-00	Montpellier
S.L.	Sharrock*	Germplasm conservation scientist	UK	07-07-96	Montpellier
S.	Soldevilla-Canales	Consultant, National Co-director, Organic Banana project, Bolivia	Peru	16-09-03	Bolivia
J.W.	Ssennyonga	Consultant, Impact Assessment project	Uganda	06-08-03	Uganda
R.	Swennen	Honorary Research Fellow	Belgium	01-12-95	KUL, Belgium
J.	Tetang Tchinda	Regional Information Officer for Africa	Cameroon	15-08-02	Cameroon
T.	Thornton*	Financial Manager	UK	01-08-90	Montpellier
I.	Van den Bergh	Associate Scientist, *Musa* Technology Transfer	Belgium	01-10-97	Philippines
I.	Van den Houwe	Officer in Charge ITC	Belgium	01-02-92	ITC, Belgium
L.	Vega	Programme Assistant	Costa Rica	01-02-92	Costa Rica
A.	Vézina	Editor, Scientific Writer	Canada	15-07-02	Montpellier
T.	Vidal	Computer Network Administrator	France	01-10-03	Montpellier
A.	Vilarinhos	Associate Scientist, Molecular biology	Brazil	01-09-00	Montpellier
J.	Vilmaers	Research Technician	Belgium	01-01-97	ITC, Belgium
S.	Voets	Germplasm Conservation Scientist	Belgium	01-01-93	ITC, Belgium

** left during the year.*

List indicates members of the INIBAP programme of IPGRI. In addition, staff within other programmes and departments of IPGRI contributed to the INIBAP programme during 2003.

Acronyms and abbreviations

ADRA	Adventist Development and Relief Agency, Tanzania
ARDI	Agriculture Research and Development Institute, Tanzania
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BAC	bacterial artificial chromosome
BAPNET	Banana Asia and Pacific Network
BARI	Bangladesh Agricultural Research Institute
BARNESA	Banana Research Network for Eastern and Southern Africa
BBTV	banana bunchy top virus
BPI	Bureau of Plant Industries, Philippines
BRIS	Banana Research Information System, INIBAP
BSV	banana streak virus
BTI	Boyce Thomson Institute for Plant Research, United States of America
CAB	Center for Agricultural Biotechnology, Thailand
CARBAP	Centre africain de recherches sur bananiers et plantains, Cameroon
CARDER	Centre d'action régionale pour le développement, Benin
CARDI	Cambodian Agricultural Research and Development Institute
CATAS	Chinese Academy of Tropical Agricultural Sciences
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
CBD	Convention on Biological Diversity
CEDAF	Centro para el Desarrollo Agropecuario y Forestal, Dominican Republic
CENARGEN	Centro Nacional de Pesquisa de Recursos Geneticos y Biotecnologia, Brazil
CFC	Common Fund for Commodities, Netherlands
CGIAR	Consultative Group on International Agricultural Research
CIB-UNALMED	Corporación para Investigaciones Biológicas – Universidad Nacional de Colombia
CIBE	Centro Investigaciones Biotecnológicas del Ecuador
CICAD-OAS	Inter-American Drug Abuse Control Commission of the Organization of the American States
CICY	Centro de Investigaciónes Científicas de Yucatán, Mexico
CINVESTAV	Centro de Investigación y de Estudios Avanzados del IPN, Mexico
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement, France
CNPMF	Centro Nacional de Pesquisa, de Mandioca e Fruticultura, Brazil
CNRA	Centre National de Recherche Agronomique, Côte d'Ivoire
CORBANA	Corporación Bananera Nacional, Costa Rica
CORPOICA	Corporación Colombiana de Investigación Agropecuaria, Colombia
CRI	Crops Research Institute, Ghana
CSIR	Council for Scientific and Industrial Research, Ghana
CTA	Technical Centre for Agriculture and Rural Cooperation ACP-EU
DA-BAR	Department of Agriculture – Bureau of Agricultural Research, Philippines
DFID	Department for International Development, United Kingdom
DGDC	Directorate General for Development Cooperation, Belgium
DNA	deoxyribonucleic acid
DPI	Department of Primary Industries, Australia
DRC	Democratic Republic of Congo
EAHB	East African highland banana
ECS	embryogenic cell suspension
EMBRAPA	Empresa Brasiliera de Pesquisa Agropecuaria, Brazil
ESPOL	Escuela Politécnica del Litoral, Ecuador
EST	expressed sequence tag
ETH	Eidgenössische Technische Hochschule Zürich, Switzerland
FABI	Forestry and Agricultural Biotechnology Institute, South Africa
FADECO	Family Alliance for Development and Cooperation, Tanzania
FAO	Food and Agriculture Organization of the United Nations, Italy
FAOSTAT	FAO statistical databases (http://apps.fao.org/default.jsp)
FARA	Forum for Agricultural Research in Africa
FFTC	Food and Fertilizer Technology Center, Philippines
FHIA	Fundación Hondureña de Investigación Agrícola
FONTAGRO	Fondo Regional de Tecnología Agropecuaria, USA
FUNDAGRO	Fundación para el Desarrollo Agropecuario, Ecuador
GAAS	Guangdong Academy of Agricultural Sciences, China
GIS	geographic information system
GM	genetically modified
HORDI	Horticultural Research and Development Institute, Sri Lanka
hpt	hygromycin phosphotransferase
IAEA	International Atomic Energy Agency
HRI	Horticultural Research Institute, Thailand
IBP	Instituto de Biotecnologia de las Plantas, Cuba
ICHORD	Indonesian Center for Horticulture Research and Development, Indonesia
IDIAF	Instituto Dominicano de Investigaciones Agropecuarias y Forestales, Dominican Republic
IDIAP	Instituto de Investigaciones Agropecuarias de Panamá
IDRC	International Development Research Centre, Canada
IEB	Institute for Experimental Botany, Czech Republic
IFAD	International Fund for Agricultural Development, Italy
IFPRI	International Food Policy Research Institute, USA
IICA	Institut Interaméricain de Coopération pour l'Agriculture, Haiti
IIHR	Indian Institute of Horticultural Research
IITA	International Institute for Tropical Agriculture, Nigeria
IITA-ESARC	IITA- Eastern and Southern Africa Regional Centre, Uganda
IMTP	International *Musa* Testing Programme
INERA	Institut National pour l'Etude et la Recherche Agronomiques, Democratic Republic of Congo
INIA	Instituto Nacional de Investigacao Agronomica, Mozambique
INIA	Instituto Nacional de Investigaciones Agrícolas, Venezuela
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuarias, Mexico
INRAB	Institut national de recherché agricole du Bénin
IPB	Institute for Plant Breeding, Philippines
IPGRI	International Plant Genetic Resources Institute, Italy
IPM	integrated pest management
IRAG	Institut de Recherche Agronomique de Guinée, Guinea
ITC	INIBAP Transit Centre, Belgium
ITSC	Institute of Tropical and Subtropical Crops, South Africa
JIC	John Innes Centre, United Kingdom
KARI	Kenyan Agricultural Research Institute
KULeuven	Katholieke Universiteit Leuven, Belgium
MARDI	Malaysian Agricultural Research and Development Institute
MAS	Myanmar Agriculture Service
MGIS	*Musa* Germplasm Information System
MGRC	*Musa* Genomics Resources Centre, Czech Republic
MINAG	Peruvian Ministry of Agriculture
MIPS/GSF	Munich Information Center for Protein Sequences/ Forschungszentrum für Umwelt und Gesundheit, Germany
MTA	material transfer agreement
MUSACO	*Musa* Research Network for West and Central Africa
MUSALAC	Plantain and Banana Research and Development Network for Latin America and the Caribbean
MUSALIT	INIBAP bibliographic database
NABC	National Agricultural Biotechnology Centre, Uganda
NARI	National Agricultural Research Institute, Papua New Guinea
NARO	National Agricultural Research Organization, Uganda
NARS	national agricultural research systems
NGO	non-governmental organization
NIAS	National Institute of Agrobiological Sciences, Japan
NRCB	National Research Centre on Banana, India
NRMDC	National repository, multiplication and dissemination centre
NSF	National Science Foundation, United States of America
PCR	polymerase chain reaction
PGRFA	plant genetic resources for food and agriculture
PMSF	phenyl methane sulphonyl fluoride
PPRI	Plant Protection Research Institute, South Africa
PRI	Plant Research International, the Netherlands
PROMUSA	Global Programme for *Musa* Improvement
RFLP	restriction fragment length polymorphism
RISBAP	Regional Information System for Banana and Plantain in Asia and the Pacific
SACCAR	South African Centre for Cooperation in Agricultural Research, Botswana
SAGE	serial analysis of gene expression
SARI	Southern Agricultural Research Institute, Ethiopia
SCAU	South China Agricultural University
SPC	Secretariat of the Pacific Community, Fiji
TARGET	Technology Applications for Rural Growth and Economic Transformation, United States of America
TBRI	Taiwan Banana Research Institute
TIGR	The Institute for Genomic Research, United States of America
UCL	Université Catholique de Louvain, Belgium
UEM	University Eduardo Mondland, Mozambique
UK	United Kingdom
UM	University of Malaysia
UNAN-LEON	Universidad Nacional Autónoma de Nicaragua-León
UPM	Universiti Putra Malaysia
USAID	United States Agency for International Development
Utolima	Universidad del Tolima, Colombia
VASI	Vietnam Agricultural Science Institute
VIMDESALT	Viceministerio de Desarrollo Alternativo, Bolivia
VVOB	Vlaamse Vereniging voor Ontwikkelingsamenwerking en Technische Bijstand, Belgium
WECARD	West and Central African Council for Agricultural Research and Development
WV Ghana	World Vision Ghana

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